A WEBINAR

ON

"SCIENCE IN OUR CULTURE"

Presented by:

Kamalakanta Jena

Associate Professor in Physics & P.G. Co-ordinator,

Bhadrak Auto College, Bhadrak.

on

24TH SEPTEMBER 2020

DEPARTMENT OF PHYSICS

PATTAMUNDAI COLLEGE

PATTAMUNDAI

REPORT

A Webinar was organized by Department of Physics, Pattamundai College, Pattamundai on 24.09.2020 on the Topic "**SCIENCE IN OUR CULTURE**". Prof. Kamalakanta Jena , Associate Professor of Physics, Bhadrak Autonomous College, was the Resource person for the Webinar. In this Webinar, Dr. Ramesh Kumar Sahoo, Head of the Department, gave a key note of the Topic. Principal Prof. Adhikari Laxminarayan Dash welcomed the guest and participants. Sri Baikunth Charan Roul introduced guest of the webinar. The webinar was ended with a vote of thanks by Dipika Rani Dash, a student of +3 3rd year Science.

Dr. Ramesh Kumar Sahoo
H.O.D. and Convenor

OFFICE OF THE PRINCIPAL
Mobile : 9437376724

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Ref No. : 880 Date 18/9/2020

To

Mr. Kamalakanta Jena (O.E.S-1)
Associate Professor in Physics & P.G Co-ordinator
Bhadrak Auto College, Bhadrak.

Sub :- Invitation to act as Resource Person in Extramural Webinar

Sir,

You are cordially requested to act as Resource Person for the Physics Webinar on "**Science in our culture**" to be held on 24 .09.2020 at 12.15 pm.

Your consent in this regard is highly solicited.

Yours

18.9.20

Principal
Pattamundai College,

Gmail **Principal Pattamundai College <pattamundaicollege@gmail.com>**

Invitation for Resource Person

2 messages

Principal Pattamundai College <pattamundaicollege@gmail.com> Fri, Sep 18, 2020 at 3:03 PM
To: kkjena1@gmail.com

attachment file
Principal
Pattamundai College
pattamundaicollege@gmail.com

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Kamalakanta Jena <kkjena1@gmail.com> Fri, Sep 18, 2020 at 4:44 PM
To: Principal Pattamundai College <pattamundaicollege@gmail.com>

Thank you sir. It is my pleasure.

KKJena
[Quoted text hidden]

C.V. of Resource Person Prof. KamalaKanta Jena

Prof. Kamalakanta Jena is presently working as an Associate Professor of Physics at Bhadrak Autonomous College, Bhadrak. He is Life member of Odisha Physical Society and editor of Physics Magazine 'DIGBALAYA'. Prof. Jena is popular writer and he has written more than five hundred Science articles. His area of research is Nuclear Physics and he has submitted more than five research papers to Modern Physics Letter E (MPLE) for publication.

DEPARTMENT OF PHYSICS
PATTAMUNDAI COLLEGE , PATTAMUNDAI

Organises
A Webinar on

"SCIENCE IN OUR CULTURE"

Date: 24.09.2020 , Time:12.15 P.M.

RESOURCE PERSON
Mr. Kamalakanta Jena (O.E.S-1),
Asso. Prof. in Physics & P.G. Co-ordinator
Bhadrak Auto College, Bhadrak,Odisha

Prof. A.L.N Dash
Principal
Pattamundai College
Pattamundai

Dr. Ramesh Kumar Sahoo,
H.O.D Physics& Convenor

Mr. Baikuntha Charan Roul
Sr. Lect. &
Co-Convenor

SCIENCE IN OUR CULTURE

Presented

By

Kamalakanta Jena

Assiciate Professor Bhadrak Autonomous College

BHADRAK

Our culture is an ancient and one of the most popular culture in the world. India is very well known for its rich culture heritage which is a combination of customs, traditions, lifestyle, religion, language, rituals, cuisine etc. It is a culture of exuberant diversity. Many aspects of our culture and traditions are quite scientific which is not known to vast public.
Here, we analysis some of the cases:

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1. Joining Both Palms Together to Greet

In our culture , people greet each other by joining their palms-termed as "Namaskar". The general reason behind this tradition is that greeting by joining both the palms means respect. However, Scientifically speaking, joining both the hands ensure joining the tips of allthe fingers together, which are denoted to the pressure points of eyes, ears and mind pressing them together is said to activatethe pressure points which helps us remember that person for a long time.

2. Wearing of Toe Rings:

Wearing toe rings is not just the significance of married women but there is scientific reason behind it. Normally toe rings are worn on the second toe. A particular nerve from the second toe connects the uterus and passes to heart. Wearing toe ring on this finger strengthens the uterus. It will keep menstrual cycle regularized. As silver is a good conductor , it also absorbs polar energie from the earth and passes it to the body.

3. Throwing coins into Rivers

The general perception for this act is that it brings Good Luck. However, scientifically, in the ancient tomes, most of the currency used was made of copper. Copper is a vital metal which is very useful to the human-body. Throwing coins in the river was one way it was ensured we intake sufficient copper as part of the rivers were the only source of drinking water. Making it a custom ensured that all of us follow the practice.

4. Applying Tilak/kumkum on the forehead:

On the forehead between the two eyebrows, is a spot that is considered as major nerve point in human-body . The Tilak is believed to present the loss of "ENERGY", the red "KUMKUM" between the eyebrows is said to retain energy in the human-body and control the various levels of concentration while applying kumkum the points on the mid-brow region and Adnya-chakra is automatically passed. This also facilitates the blood supply to the face muscles.

5. Bells in Temples:

People who are isiting the temple would ring the bells before entering the inner Sanctum (Grabha Gruha) where the main idol is placed . According general perception, the bell is used to give sound for keeping evil forces away and the ring of the bell is pleasant to God. However, the Scientific reason behind bells is that their rings cleans our mind and helps us stay sharp and keep our full concentration on devotional purpose. These bells are made in such a way that when they produce a sound it creates a unity in our brains. The moment we ring the bells, it produces a sharp and enduring sound which lasts for minimum of 7 seconds in echo mode. The duration of echo is good enough to activate all the seven heading centers in our body.

6. Why We start with Spice and end with Sweet:

Our ancestors have *stressed* on the fact that our meals should be started off with something spicy and sweet dishes should be taken towards the end. The significance of this eating practices is that while spicy things activate the digestive juices and cids and ensure that the digestion process goes on smoothly and efficiently. Sweets or carbohydrates pulls down the digestive process. Hence, sweets were always recommended to be taken as the last item.

7. Why do we applying Mehendi on the hand feet:

Besides lending colour to the hands, Mehendi is a very powerful medicinal herb. It cools the body and keeps the nerves from becoming tense. This is the reason why mehendi applied on the hands and feet, which house nerve endings in the body.

8. Sitting on the floor and eating:

This tradition is not just about sitting on floor and eating, it is , sitting in the "SUKHASANA" position and then eating. SUKHASANA is the position we normally use for Yoga asanas. It helps in digestion.

9. Why We should not sleep with our head towards north:

Myth is that it involves ghost or death but scientifically it is because human body has its own magnetic field and Earth is a giant magnet. When we sleep with head towards north, our body's magnetic field become completely asymmetrical to the earth's magnetic field. That causes problem related to blood pressure and our heart needs to work harder in order to overcome this asymmetry of magnetic fields.

10. Fasting:

Ancient Indian Medical system points out correctly that the basic cause of many diseases is the accumulation of toxic material in the digestive system. Regular cleaning of toxic materials keeps one healthy. By fasting, the digestive organs get rest and all body mechanisms are cleaned and corrected. A complete fasting is good for health and occasional intake of warm lemon juice during the period of fasting prevents the flatulence.

Thank you all


REC
Galaxy A31
Kamalakanta Jena
Bibhupada Roy
Pradosh


12:25
REC
Madhusudan Behera
Pattamundai College
Dr. C.R.Mishra
Kamalakanta Jena

Participants (52)

SP Smita Prakash Biswal

SD Smrutirekha Das

srinibash sahoo

SM Srutisudha Mishra

Stiti Rout

Subhasis Mishra

S Sujit

SN Suraj Nayak

SL SUVAM LENKA

VL vivo linu

S Aditya narayan rout

DD DR.MITHILA DAS

GM Ganeswar mallik

P Pradosh

S Suchismita Parida

Participants (53)

- Deepika Dash
- DR KISHORA KUMAR BEDANTA
- Dr. C.R.Mishra
- Galaxy A31
- Geeta Maha
- Guruprasad Sahoo
- John Cena
- Kalipada giri
- Madhusmita Das
- Monalisha dash
- Mr. p n Rath
- Nibedita Patra
- OPPO A71 (3GB)
- PRADEEP, Department of Physics
- Preetam Jena

12:33

Close

Participants (54)

MB Madhusidan Behera (me)

Pattamundai College (Host)

Kamalakanta Jena

A AJAY KUMAR KUND

AM Alok Mallik

AM Aparna Moharana

AN Asima natha

BC Baikunth Charan Roul

BAL GOPAL MAHAPATRA

B Barsha

BP BASUDEV PADHI

BM Bhagyashree Mohanty

BR Bhagyashree rout

B BIBHUDATTA PANDA

D Deepali

12:34

Close Participants (53)

- PD Priyadarshini Dash
- PS puja satapathy
- SD Sabyasachi Dash
- SJ sarojini jena
- SM Satyajit mahalik
- shraddhanjali samal
- SR Silpa rani Das
- SP Smita Prakash Biswal
- SD Smrutirekha Das
- srinibash sahoo
- SM Srutisudha Mishra
- Stiti Rout
- Subhasis Mishra
- S Sujit
- SN Suraj Nayak

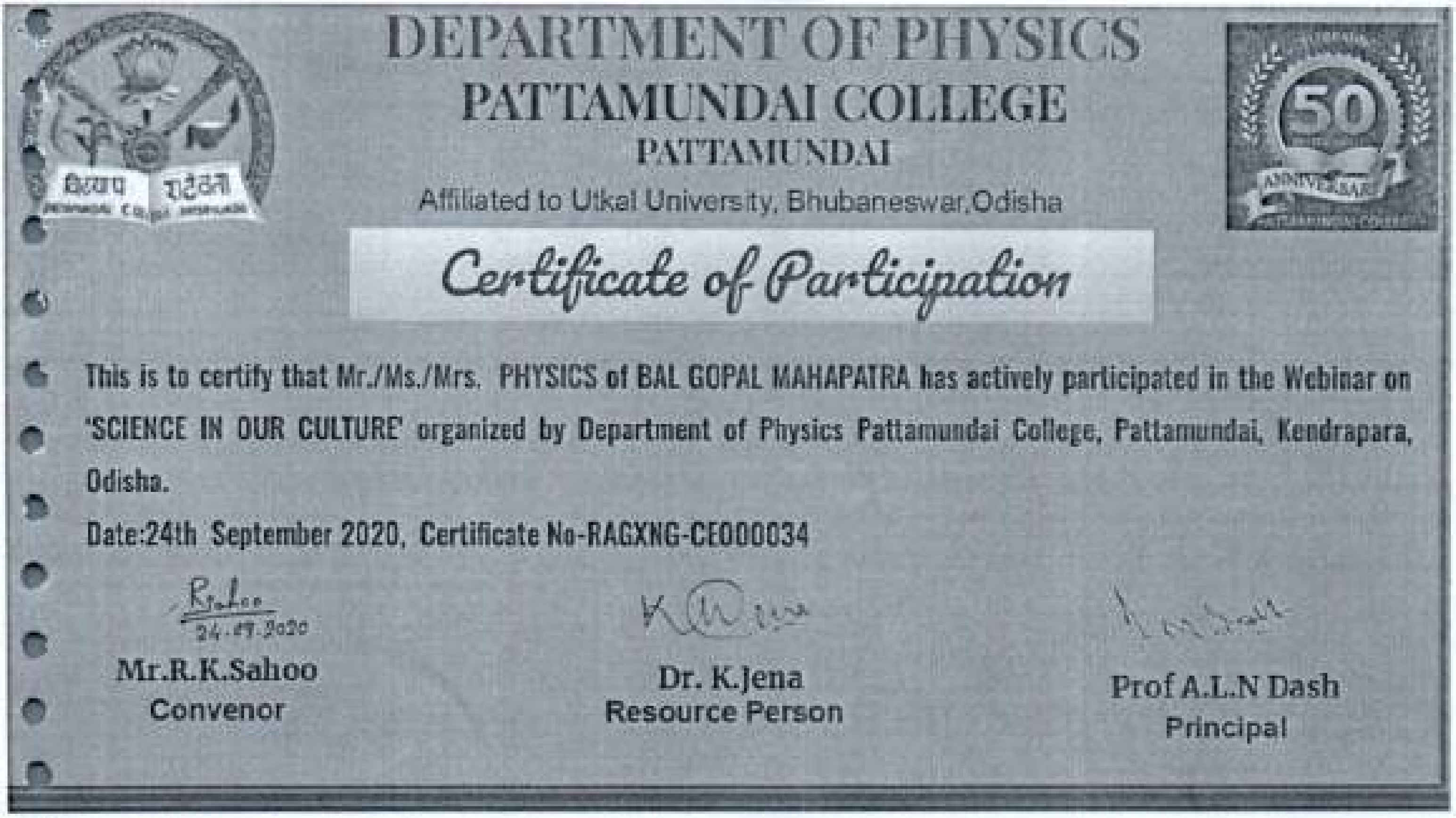
Registration List For the Webinar "SCIENCE IN OUR CULTURE"

Organised by Department of Physics, Pattamundai College, Pattamundai (Date:24.09.2020)

SL. NO.	Email Address	FULL NAME (IN CAPITAL LETTERS)	Designation	Class (Only for Students)	Roll No (Only For Students)	Department	Mobile No.
1	madhusudanbehera257@gmail.c	MADHUSUDAN BEHERA	Student	3	Bs18 058	Physics	9348656306
2	sarangibijayalaxmi100@gmail.co	BIJAYALAXMI SARANGI	Student	+33rd yr	BS17- 129	Physics	8917509543
3	Kalipadagiri64@gmail.com	KALIPADA GIRI	Student	+3 3rd Year	BS18-034	PHYSICS	8114716537
4	sarojinimishra7191@gmail.com	SAROJINI MISHRA	Lecturer			zoology	9437920782
5	prajnanandarath@gmail.com	PRAJNANANDA RATH	Student	+3 3rd year science	BS18-090	Physics	7608830889
6	srinibash19sahoo@gmail.com	SRINIBASH SAHOO	Student	+3,3rd year (phy. Hons.)	BS17-064	Physics	8917398157
7	radharanidas27@gmail.com	RADHARANI DAS	Student	Msc	1.80705E+11	Physics	8144190551
8	deepikadash001@gmail.com	DIPIKA DASH	Student	+3 3rd year BSc.	76	Physics	7325825393
9	ashismallick934@gmail.com	ASHIS KUMAR MALIK	Student	+3 2nd year	Bs-18-141	Physics	9114356504
10	silpasilpa519@gmail.com	SILPARANI DAS	Student	+3 3rd year	BS17-150	Physics	9556386618
11	chinmayaprasadbarik@gmail.con	CHINMAYA PRASAD BARIK	Student	+3 final year science. physic	BS17-123	Physics	8249619984
12	deepalisahoo62511@gmail.com	DEEPALI SAHOO	Student	+3 3rd yr	Bsc17-117	Physics	7894820597
13	subhakantalenka789@gmail.com	SUBHAKANTA LENKA	Student	3rd year	Bs17-154	Physics	9337769624
14	subhasmitarout3333@gmail.com	SUBHASMITA ROUT	Student	+3 3rd yr science	Bs17-044	Physics	7077101014
15	baikunthroul1@gmail.com	BAIKUNTH CHARAN ROUL	Lecturer			Physics	9337127295
16	rogergunu18@gmail.com	SATYARANJAN PATRA	Student	Awasomr	BS-18-030	PHYSICS	9668256943
17	rajeshkumarroul3@gmail.com	RAJESH KUMAR ROUL	Student	BSc second year	BSc(P) -19-002	Physics	7735916403
18	suvamlenka1234@gmail.com	SUVAM LENKA	Student	+3 3rd year student	BS18-050	Physics	7325899029
19	excellentsaroja@gmail.com	SAROJAKANTA NAYAK	Lecturer			English	9583371671
20	dparida1965@gmail.com	DR DUSHASAN PARIDA	Reader			CHEMISTRY	9853165455
21	laxmipriya20111@gmail.com	LAXMIPRIYA SAHOO	Student	+3 final year ,science(Phys	BS17-032	Physics dept	8328812331
22	pradosh157@gmail.com	PRADOSH RANJAN PANI	Lecturer			Physics	9853036566
23	nibeditanayak63@gmail.com	MRS NIBEDITA NAYAK	Lecturer			department of educatio	9668725524
24	nilamani.lenka00@gmail.comni	DR.NILAMANI LENKA	Reader			ODIA	9438329950
25	shraddhanjali33@gmail.com	SHRADDHANJALI SAMAL	Student	+3 3rd year	Bs-18-136	Physics	9348452613
26	dashp496@gmail.com	Mr. PRADEEP KUMAR DASH	Student	+3 3rd year (5th semester)	BS18-072	Department of Physics	9.16371E+11
27	aparnamoharana495@gmail.com	APARNA MOHARANA	Student	+3 3 rd year	BS-18-132	Physics	7735658508
28	biswaranjansahoo658@gmail.co	BISWARANJAN SAHOO	Student	Post 3rd year	BS17-155	PHYSICS	9078084241
29	khannousad6@gmail.com	NOUSAD KHAN	Student	+3 3rd year	BS 17-007	Physics	8117025015
30	stitirout@gmail.com	STITI ROUT	Student	+3 3rd year	BS18-005	Physics	7205306130
31	abinashgahan317@gmail.com	Abinash Kumar Gahan	Student	+3 3rd year	BS18-120	PHYSICS	7681893549
32	ajayamaharana22@gmail.com	AJAYA KUMAR MAHARANA	Demonstrater in physics			Physics	8917509637
33	smitaprakash2018@gmail.com	SMITA PRAKASH BISWAL	Student	+3,2nd year	110	Physics	7008138081

34	soumyasonu304@email.com	SOUMYA RANJAN BEHERA	Student	+3 3rd year	Bs_18_021	Physics	9348849906
35	bibhudattapanda34@gmail.com	BIBHUDATTA PANDA	Student	+3 3rd year	BS18-109	Physics	9777028363
36	asimanath430@gmail.com	ASIMA NATH	Student	+3 1st year	BS(P) -19-030	PHYSICS	7978687983
37	2000Kshirodkumar@gmail.com	KHIROD KUMAR SETHI	Student	+3 3rd year scince(Physics	Bs17_138	Physics	9178096187
38	priyadadarshanisahoomanu@gm	PRIYADARSHANI SAHOO	Student	+3 3rd yr	BS18-52	Dept. Of Zoology, Rajka	6372042342
39	gedimanaswini@gmail.com	Manaswini Gedi	Student	Bsc 2nd yr	53	Zoology	9668039190
40	pandasupriya742@gmail.com	Supriya panda	Student	+3 2nd year	BS(B)19-030	Zoology	9937269862
41	dilipbhuyan1965@gmail.com	DILLIP KUMAR BHUYAN	Reader			Zoology	9437383989
42	bhajaharimohanty26@gmail.com	Sujata Mohanty	Student	+3 2nd year sci.	89	Zoology	9937886739
43	rouljayashree63@gmail.com	JAYASHREE ROUL	Student	BSc 2nd year	32	Zoology	9668777997
44	dassanjayakumar65@gmail.com	SANJAYA KUMAR DAS	Student	+33rd yr	202	Zoology	6370487537
45	supritisahoo049@gmail.com	Supriti sahoo	Student	+3 2nd year	33	Zoology	8280112591
46	sujitkumarswain321@gmail.com	SUJIT KUMAR SWAIN	Student	+3 3rd year	Bs-18-085	Physics	6370806873
47	singh.pujarchana2001@gmail.co	PUJARCHANA SINGH.	Student	+3 3rd yr	14	Zoology	9668795746
48	jenapreetam08@gmail.com	PREETAM JENA	Student	+3 3rd yr science	BS18-061	Physics	7325878794
49	nsikha055@gmail.com	SIKHA NAYAK	Student	+3 3rd year	Bs18-006	Zoology	6370176916
50	nayakliparani550@gmail.com	LIPARANI NAYAK	Student	+3 3rd year Sc.	BS18-038	Dept. of zoology	8917531991
51	sahoopradyumna55@gmail.com	PRADYUMNA KUMAR SAHOO	Student	+3 2nd year science	143	Zoology	7735061658
52	nayakshilarani@gmail.com	SHILARANI NAYAK	Student	Bsc.2nd year	22	Zoology	7751818513
53	pujasatapathy6@gmail.com	PUJA SATAPATHY	Student	+3 3rd year	BS18-115	Physics	9938009631
54	drpksamal1963@gmail.com	DR. PRAMOD KUMAR SAMAL	Reader			Historic	9337143523
55	madhusmitananda234@gmail.co	MADHUSMITA NANDA	Student	+3 3rd year	BS18-141	Zoology	7735927792
56	biswaldivyabharati@gmail.com	DIVYABHARATI BISWAL	Student	+3 2 nd year (science)	79	Zoology	7077348782
57	prajnadash167@gmail.com	PRAJNA PARAMITA DASH	Student	+3 third year student	147	Zoology	8878884769
58	ranjankumargahan746@gmaail.c	RANJAN KUMAR GAHAN	Lecturer			Chemistry	7735355311
59	manaswinimohanty63@gmail.co	MANASWINI MOHANTY	Student	+3 2nd yr	BS(B) 19-161	Zoology	6372733430
60	rkpandaodca2008@gmail.com	RABINDRA KUMAR PANDA	Lecturer			History	9238899769
61	nibeditapatra161@gmail.com	NIBEDITA PATRA	Student	+3 3rd Year	BS17-120	Physics	7377758748
62	sabyasachidash1999@gmail.com	SABYASACHI DASH	Student	+3 3rd year	BS18-011	Chemistry	8763630790
63	bhagyashreerout127@gmail.com	Bhagyashree rout	Student	+3 2 nd year	Bs-19-111	Physics	6370257746
64	www.satyajitmahalik527@gmail.	SATYAJIT MAHALIK	Student	+3,3rd yr	BS18-062	Department of physics,	7326941655
65	janmejaypradhan567@gmail.com	Janmejay Pradhan	Student	+3 6th semester	BS17-146	Physics	8249435119
66	padhibasudev146@gmail.com	BASUDEV PADHI	Student	+3 2nd Year physical scienc	BS(P)19-103	Physics	9668440946
67	soubhagyaallinone@gmail.com	ADITYA NARAYAN ROUT	Student	+3 2nd year physics	BS19-115	Physics	7751041659
68	smrutirekhasniki@gmail.com	SMRUTI REKHA DAS	Student	+3 2nd yr	BS-19-105	Physics	7992916924
69	santoshmishra1084@gmail.com	SRUTISUDHA MISHRA	Student	+3 2nd year	BS(P)19-014	Physics	9861073955
70	rajeshkanha4992@gmail.com	RAJESH SETHI	Student	+3 3rd Year Commerce	BC-18-107	Commerce	7377323315
71	anjanabarik440@gmail.com	ANJANA BARIK	Student	+3 2 nd year (3 rd semeste	BA-19-227	Education	9178767691

72	sarojinijena61@gmail.com	Sarojini jena	Student	+3 3rd year	BS 18-055	Physics	9556316737
73	chandankhandual736@gmail.cor	Chandan khandual	Student	3	Bs18044	Botany	6372911681
74	bulurani7894998324@gmail.com	MIRARANI ROUT	Student	+3 2nd year physics	BS19-090	Physics	7894998324
75	mithiladas.rjk@gmail.com	DR.MITHILA DAS	Lecturer			ZOOLOGY	9439051850
76	priyankapanda9918@gmail.com	PRIYANKA PANDA	Student	+3 3rd yr sc	BS18-078	Zoology	9861246892
77	bhagyashreemohanty025@gmail	BHAGYASHREE MOHANTY	Student	+3 3rd year	BS18_131	Physics	8079709181
78	ranjan775819@gmail.com	Ranjan kumar Behura	Lecturer			HISTORY	9668830365
79	sd4.subratdas@gmail.com	SUBRAT DAS	Student	B.Sc. 3rd Year	BS18-002	Zoology	9348400572
80	sunandasahoo164@gmail.com	SUNANDA SAHOO	Student	+3 3rd yr SC.	Bs18_088	Physics	7377115579
81	sangitasubhasmitaroul@gmail.cc	SANGITA SUBHASMITA ROUL	Student			Utkal University	6370747916
82	sahoobarsharani43@gmail.com	BARSHARANI SAHOO	Student	+3 3rd year	Bs18-133	Physics	7735468703
83	balgopalmahapatra69@gmail.cor	BAL GOPAL MAHAPATRA	Lecturer			Physics	7978351360
84	ganeswarmallik84@gmail.com	GANESWAR MALLIK	Student	+3 2nd year	76	Physics	8917577734
85	dasrasmirekha98@gmail.com	RASMIREKHA DAS	Student	+3 3rd year	BC-18-069	Commerce	9937223385
86	rbanya712@gmail.com	BANYARANI PARIDA	Student	+3 3rd year commerce	Bc18-134	Commerce	7077470931
87	sonalilenka235@gmail.com	SONALI LENKA	Student	+3 3rd yr.	Bc-18-121	Physics	7735697745
88	alivaa466@gamil.com	ALIVA PRIYADARSINI BHUYAN	Student	+3 3rd year	BC-18-127	commerce	9348280853
89	geetanjaliguddu69@gmail.com	Smt.Geetanjali Mahapatra.	Lecturer			Department of Zoology	7978385300
90	pradhandebasmita26@gmail.con	DEBASMITA PRADHAN	Student	+3 3rd year (commerce)	Bc-18-028	Commerce	9777269863
91	nayaksuraj067@gmail.com	SURAJNAYAK	Student	+3 3rd year	BS.18.084	Physics	9348409032
92	shalini.salu01@gmail.com	SHALINI SINGH	Student	+3 3rd year	BA18-026	Sociology	9337820354
93	daspriyankamiya@gmail.com	PRIYANKA PRIYADARSHINI JE	Student	+3 3rd year	BA-17-206	History	9937762655
94	anusayadas000@gmail.com	ANUSAYA DAS	Student	+3 3rd year	BA-18-166	HISTORY	7787823970
95	suryakantibayee@gmail.com	SURYAKANTI BAYEE	Student	+3 3rd year(Art's)	BA-18-014	SOCIOLOGY	9556836138
96	sahoopriyanka855@gmail.com	PRIYANKA SAHOO	Student	+3 3rd yr Arts	BA- 18 - 186	Physics	7681086392
97	suryakantibayee@gmail.com	CHANDRAKANTI BAYEE	Student	M.A	Enrolment No-1	History	9556836138
98	alokmallik55473@gmail.com	ALOK MALIK	Student	Student	75	Physics	7325815616
99	sulochana.dash123@gmail.com	SULOCHANA DASH	Reader			Physics	9937301194
100	sarangisandhya8@gmail.com	SANDHYA RANI SARANGI	Student	+3 3rd year	Bc- 18- 037	Commerce department	8260870313
101	monalishakunidash@gmail.com	MONALISHA DASH	Student	+3 3rd year	Bs18_039	Chemistry	6370995348
102	monalisharout865@gmail.com	MONALISHA ROUT	Student	+3 third year	BC-18-018	Commerce	8658147458
103	Swainakanksha359@gmail.com	AKANKSHA SWAIN	Student	+3 3rd yr	Bc18-031	Commerce	9348647672
104	jenapratikshya2001@gmail.com	Pratikshya jena	Student	+3 3rd year	BA18-264	Sociology	7751067003
105	jullinayak55@gmail.com	JULLI NAYAK	Student	+2 1st year	2	Arts	9938564728



DEPARTMENT OF PHYSICS
PATTAMUNDAI COLLEGE
PATTAMUNDAI

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Certificate of Participation

This is to certify that Mr./Ms./Mrs. PHYSICS of BAL GOPAL MAHAPATRA has actively participated in the Webinar on 'SCIENCE IN OUR CULTURE' organized by Department of Physics Pattamundai College, Pattamundai, Kendrapara, Odisha.

Date:24th September 2020, Certificate No-RAGXNG-CE000034

24.09.2020

Mr.R.K.Sahoo
Convenor

Dr. K.Jena
Resource Person

Prof A.L.N Dash
Principal

THE SAMAJA on 26.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ୱେବିନାର

ପଞ୍ଚାମୁଣ୍ଡାଇ, ୨୫।୯ (ନି ପ୍ର): ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଆମ ସଂସ୍କୃତିରେ ବିଜ୍ଞାନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରୋହିତ୍ୟରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ଏଥିରେ ଭଦ୍ରକ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ସହକାରୀ ପ୍ରଫେସର କମଳକାନ୍ତ ଜେନା ଆମ ଦୈନନ୍ଦିନ ଜୀବନର ବିଭିନ୍ନ କାର୍ଯ୍ୟରେ ବିଜ୍ଞାନର ପ୍ରୟୋଗ ଓ ଆମ ସଂସ୍କୃତି ସହ ବିଜ୍ଞାନର ସମ୍ପର୍କ ବିଷୟରେ ଆଲୋଚନା କରିଥିଲେ। ୱେବିନାର ଆବାହକ ତଥା ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଓ ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଚରଣ ଭୋଇ ଅତିଥି ପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ। ଛାତ୍ରୀ ଦୀପିକା ଦାସ ଧନ୍ୟବାଦ ଦେଇଥିଲେ।

Date 26.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ୱେବିନାର

ପଞ୍ଚାମୁଣ୍ଡାଇ (ସବ୍ୟୁ) : ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଆମ ସଂସ୍କୃତିରେ ବିଜ୍ଞାନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରହିତ୍ୟରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ଏଥିରେ ଭଦ୍ରକ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ସହକାରୀ ପ୍ରଫେସର କମଳାକାନ୍ତ ଜେନା ଯୋଗ ଦେଇ ଆମ ଦୈନନ୍ଦିନ ଜୀବନର ବିଭିନ୍ନ କାର୍ଯ୍ୟରେ ବିଜ୍ଞାନର ପ୍ରୟୋଗ ଓ ଆମ ସଂସ୍କୃତି ସହ ବିଜ୍ଞାନର ସଂପର୍କ ବିଷୟରେ ଆଲୋଚନା କରିଥିଲେ । ୱେବିନାର ଆବାହକ ତଥା ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତଭାଷଣ ଓ ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଚରଣ ଭୋଇ ଅତିଥିପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ । ଶେଷରେ ଛାତ୍ରୀ ଦୀପିକା ଦାସ ଧନ୍ୟବାଦ ଦେଇଥିଲେ । ଏହି ଆଲୋଚନାଚକ୍ରରେ ବହୁ ଅଧ୍ୟାପକ/ ଅଧ୍ୟାପିକା ଓ ଛାତ୍ରଛାତ୍ରୀ ଯୋଗ ଦେଇଥିଲେ ।

PRINTED IN THE SAMAYA ON 26.09.2020

Date 26.09.2020

PRAMEYA on 26.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ
ପଦାର୍ଥ ବିଜ୍ଞାନ ୱେବିନାର୍

ପଞ୍ଚାମୁଣ୍ଡାଇ,୨୫।୯(ଅପ୍ର): ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଆମ ସଂସ୍କୃତିରେ ବିଜ୍ଞାନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରହିତ୍ୟରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ଏଥିରେ ଭଦ୍ରକ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ସହକାରୀ ପ୍ରଫେସର କମଳାକାନ୍ତ ଜେନା ଯୋଗଦେଇ ଆମ ଦୈନନ୍ଦିନ ଜୀବନର ବିଭିନ୍ନ କାର୍ଯ୍ୟରେ ବିଜ୍ଞାନର ପ୍ରୟୋଗ ଓ ଆମ ସଂସ୍କୃତି ସହ ବିଜ୍ଞାନର ସଂପର୍କ ବିଷୟରେ ଆଲୋଚନା କରିଥିଲେ। ୱେବିନାର୍ ଆବାହକ ତଥା ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଓ ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଚରଣ ଭୋଇ ଅତିଥି ପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ। ଶେଷରେ ଛାତ୍ରୀ ଦୀପିକା ଦାସ ଧନ୍ୟବାଦ ଦେଇଥିଲେ। ଏହି ଆଲୋଚନାଚକ୍ରରେ ବହୁ ଅଧ୍ୟାପକ / ଅଧ୍ୟାପିକା ଓ ଛାତ୍ରଛାତ୍ରୀ ଯୋଗ ଦେଇଥିଲେ।

Date 26.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ
ପଦାର୍ଥ ବିଜ୍ଞାନ ୱେବିନାର

ପଞ୍ଚାମୁଣ୍ଡାଇ, ପିଏନଏସ: ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଆମ ସଂସ୍କୃତିରେ ବିଜ୍ଞାନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରହିତ୍ୟରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ଏଥିରେ ଭଦ୍ରକ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ସହକାରୀ ପ୍ରଫେସର କମଳାକାନ୍ତ ଜେନା ଯୋଗ ଦେଇ ଆମ ଦୈନନ୍ଦିନ ଜୀବନର ବିଭିନ୍ନ କାର୍ଯ୍ୟରେ ବିଜ୍ଞାନର ପ୍ରୟୋଗ ଓ ଆମ ସଂସ୍କୃତି ସହ ବିଜ୍ଞାନର ସଂପର୍କ ବିଷୟରେ ଆଲୋଚନା କରିଥିଲେ । ୱେବିନାର ଆବାହକ ତଥା ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତଭାଷଣ ଓ ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଚରଣ ଭୋଇ ଅତିଥିପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ । ଛାତ୍ରୀ ଦୀପିକା ଦାସ ଧନ୍ୟବାଦ ଦେଇଥିଲେ । ଏହି ଆଲୋଚନାଚକ୍ରରେ ବହୁ ଅଧ୍ୟାପକ/ ଅଧ୍ୟାପିକା ଓ ଛାତ୍ରଛାତ୍ରୀ ଯୋଗ ଦେଇଥିଲେ ।

Printed in The
Pragatibadi on
26.09.2020

Date. 26.09.2020

A WEBINAR

ON

"PHYSICS OF STARS"

Presented by:

Dr. Swagat Ranjan Das

Post Doctoral Fellow, IISER, Tirupati.

on

10TH SEPTEMBER 2020

DEPARTMENT OF PHYSICS

PATTAMUNDAI COLLEGE

PATTAMUNDAI

REPORT

A Webinar was organized by Department of Physics, Pattamundai College, Pattamundai on 10.09.2020 on the Topic "**Physics of Stars**". Dr. Swagat Ranjan Das, Post Doctoral Fellow, IISER, Tirupati, was the Resource person for the Webinar. In this Webinar, Dr. Ramesh Kumar Sahoo, Head of the Department, gave a key note of the Topic. Principal Prof. Adhikari Laxminarayan Dash welcomed the guest and participants. Sri Baikunth Charan Roul introduced guest of the webinar. The webinar was ended with a vote of thanks by Dipika Rani Dash, a student of +3 3rd year Science.

Dr. Ramesh Kumar Sahoo
H.O.D. and Convenor

OFFICE OF THE PRINCIPAL
Mobile : 9437376724

PATTAMUNDAI COLLEGE

NAAC ACCREDITED B+ GRADE
PATTAMUNDAI, KENDRAPARA, ODISHA - 754215

Ref No. : 833 Date 07/09/2020

To

Dr. Swagat Das
Post Doctoral Fellow,
Indian Institute of Science Education and Research.
Tirupati, Andhra Pradesh.

Sub: Invitation to act as the **Resource Person** in the extramural webinar.

Dear Sir,

You are cordially requested to act as resource person for the extramural webinar on the topic "**Physics of Stars**" going to be held on 10th September 2020 at 09.00 a.m organised by Department of Physics.

Your consent in this regard is highly solicited.

Yours

7.9.20
Principal
Pattamundai College.

Gmail **Principal Pattamundai College <pattamundaicollege@gmail.com>**

Invitation to Act as Resource Person

2 messages

Principal Pattamundai College <pattamundaicollege@gmail.com> Mon, Sep 7, 2020 at 1:45 PM
To: swagat407@gmail.com

Principal
Pattamundai College
pattamundaicollege@gmail.com

Invitation.pdf
119K

Swagat Das <swagat407@gmail.com> Tue, Sep 8, 2020 at 7:50 AM
To: Principal Pattamundai College <pattamundaicollege@gmail.com>

Dear Sir,
Thank you very much for this mail. I happily accept the invitation for the webinar scheduled on 10th Sep 2020.

Thank you again.

With regards,
Swagat

On 9/7/20, Principal Pattamundai College <pattamundaicollege@gmail.com> wrote:
> *Principal*
> *Pattamundai College*
> *pattamundaicollege@gmail.com <pattamundaicollege@gmail.com> *
>

C.V. of Resource Person Dr. Swagat Rannjan Das

Swagat Ranjan Das is currently working as Post-doc Fellow at Indian Institute of Science Education and Research, (IISER), Tirupati, I ndia. He has obtained his PhD degree in field of Astronomy & Astrophysics from Indian Institute of Space Science and Technology, Trivendrum, India. Prior to that he has completed his Masters degree in Physics from Sambalpur University, Sambalpur, India.

DEPARTMENT OF PHYSICS

Organises
a Webinar on

"PHYSICS OF STARS"

REACH US
Address:
Pattamundai college, Kendrapara
www.pattamundaicollege.ac.in
pattamundaicollege@gmail.com

Registration Link:-https://forms.gle/IJ9BYhFR9cdzbmEc8
Google Meet Link:-https://meet.google.com/aqi-wfnq-bho

Date: 10.09.2020 , Time:09 A.M

RESOURCE PERSON
Dr. Swagat Ranjan Das,
Post Doctoral Fellow, Indian Institute of Science Education and Research, Tirupati, Andhra Pradesh

Prof. A.L.N Dash
Principal
Pattamundai College
Pattamundai

Dr. Ramesh Kumar Sahoo,
H.O.D Physics, Convenor

Baikuntha Charan Roul,
Co-Convenor cum Sr. Lr. In Physics

OFFICE OF THE PRINCIPAL
PATTAMUNDAI COLLEGE, PATTAMUNDAI

No. 837 dt. 07/09/20

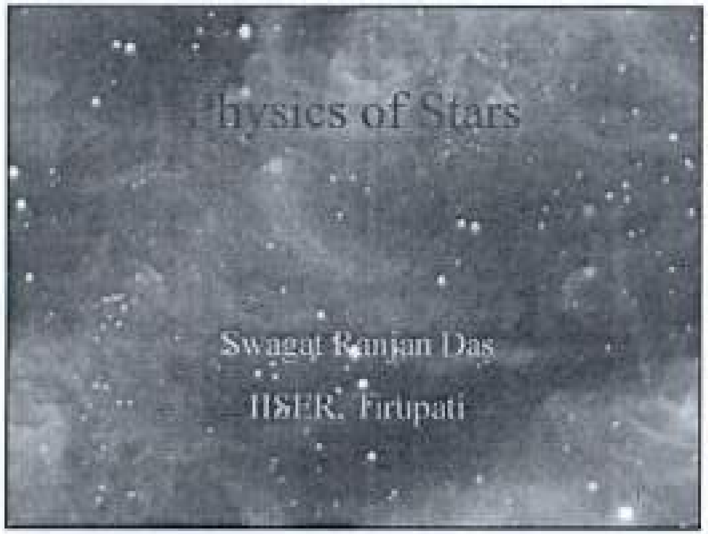
NOTICE

All the staff members are requested to participate and co-operate in the Extramural Webinar on, "**Physics of Stars**" to be organized by the Department of Physics at **09.00 am on 10th September 2020**.

7.9.20

Principal
Pattamundai College
Principal
Pattamundai College

Copy to the Staff Common Room/Guard File.

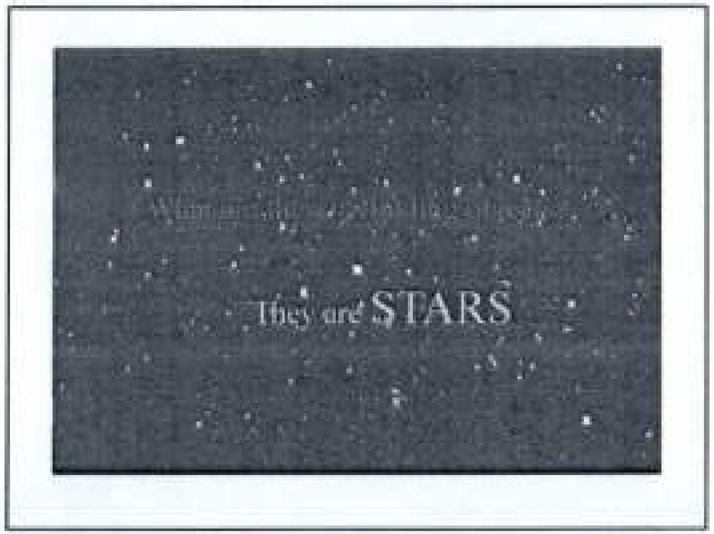


Physics of Stars

Swagat Ranjan Das

IISER, Tirupati

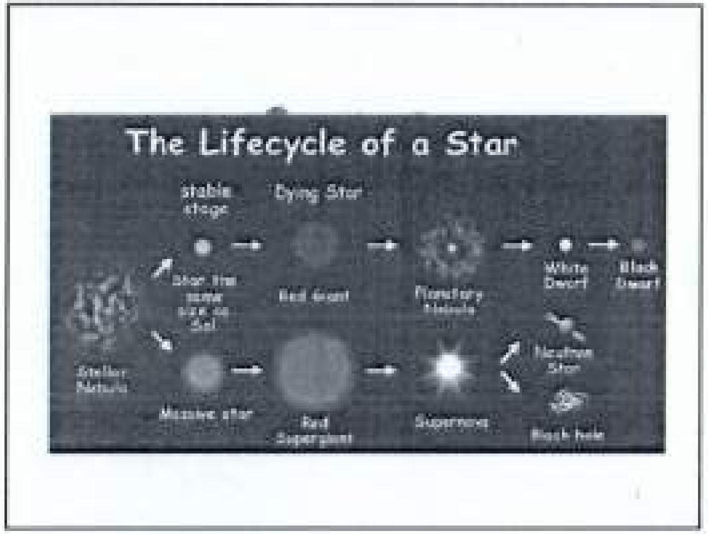
1



[illegible]

They are STARS

2

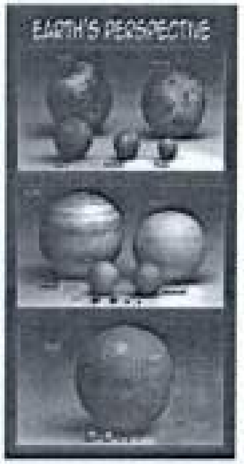


The Lifecycle of a Star

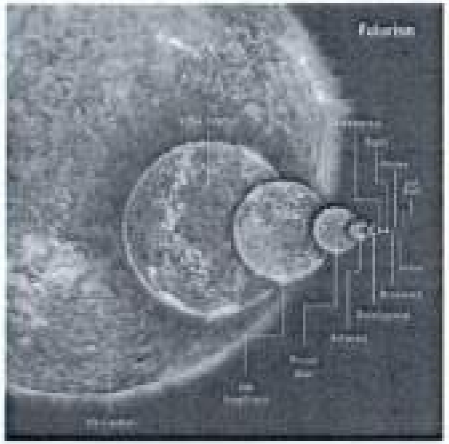
3

It contains about 10^{11} stars, plus gas and dust between the stars (the interstellar medium)

4



Planet	Diameter (km)	Distance from Earth (km)	Apparent or Angular Size (degrees)
Sun	1.39 million	149.2 million	0.53
Mercury	4879	91.726 million	0.00303
Venus	12,104	41.84 million	0.01658
Earth	12,756	-	-
Moon	3,475	385,000	0.52
Mars	6794	78 million	0.00497
Jupiter	142,984	591 million	0.01385
Saturn	120,536	1.197 billion	0.00576
Uranus	51,118	2.586 billion	0.00113
Neptune	49,528	4.312 billion	0.00066
Pluto	2390	4.286 billion	0.00003



What is a Star?

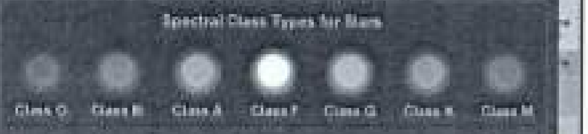
- In lay terms, a star is a big b
- More technically, a star is a conditions:
- It is bound by self-gravity
  - Spherical due to the symmetric nature of gravity
- It radiates energy
  - Nuclear energy rele interior

Classification of stars?

- Astronomers classify stars (spectral types) based on the relative strengths of their absorption lines
- Spectral sequence: O B A F G K M
  - type A has the strongest H lines
- Each spectral type is further divided into 10 subclasses e.g. A0, A1, A2, … , A9, F0, F1, …

Spectral Class

(Oh Boy, A Failing Grade Kills Me)



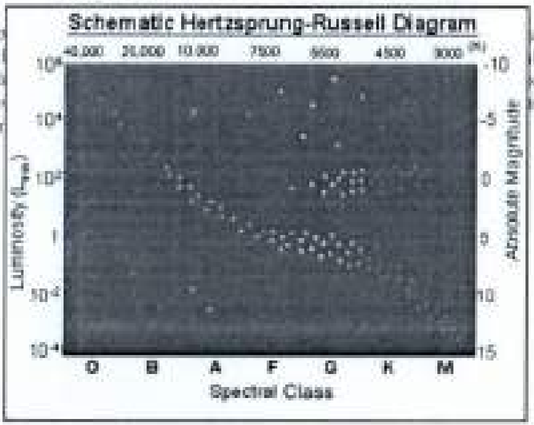
- Determined by analyzing a star's spectra
- O stars are the hottest and most massive
- stars are the and
- Our Sun is a G star

Oh Be A Fine Girl/Guy, Kiss Me!

- Late 1890s: at this time the energy-level structure of atoms was not known. Stars were classified according to the strength of hydrogen Balmer lines with classes that were assigned a letter from A to O (from the strongest to the weakest).
- "Henry Draper Catalogue", published by astronomers at the Harvard College Observatory. It listed 225,300 stars.
- The classification sequence included 7 categories named with letters: O,B,A,F,G,K,M. The sequence is solely based on the progression of line patterns in the spectra (A. Maury). Many of the original classes from A through O were dropped, and the order was changed! See later why...
- A.J. Cannon refined the sequence into subclasses (e.g., from G0 to G9).

The Hertzsprung-Russell Diagram

Hertzsp ainst its
spectral ll at the
same d ame in
lumino s of the
diagram



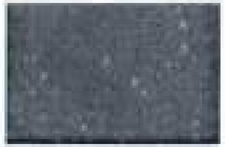
Sites of Star formation

Star-forming regions are seen in our galaxy as well as others.
Star formation begins in massive clouds of molecular gas and dust

Giant Molecular Clouds (GMCs):

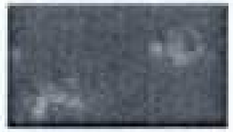
- Mass = 10^4 -10^6 $M_\odot$
- Distance to nearest GMC = 140 pc (Taurus)
- Typical size = 5-100 pc
- Average temperature (in cold parts) = 20-30 K
- Typical density = 10^2 -10^6 cm^{-3}
- Typical (estimated) life time ~10^7 year
- Star formation efficiency ~1-10%

Few nearby GMCs



- Distance ~ 140 pc
- Size ~ 30 pc,
- Mass ~ 10^4 $M_\odot$

- Distance ~ 140 pc
- Size ~ 6 pc,
- Mass ~ 10^4 $M_\odot$



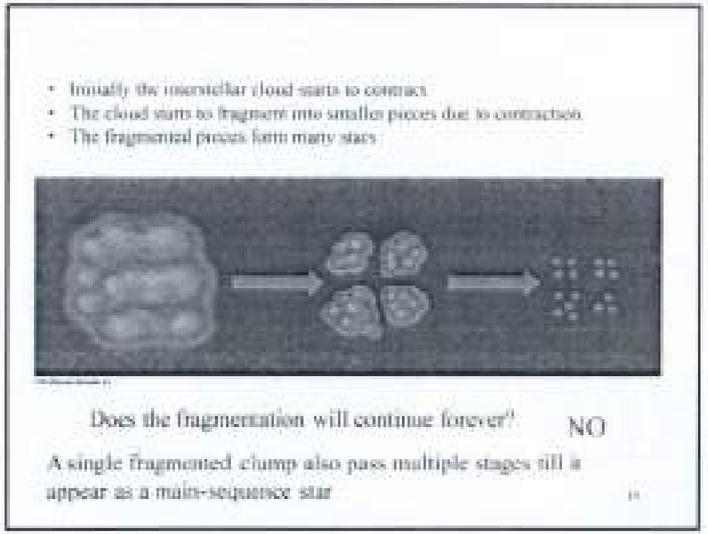
- Distance ~ 400 pc
- Size ~ 60 pc,
- Mass ~ 10^5 $M_\odot$

How stars form?

- Stars form when dust cloud (or part of it) starts to contract under its own gravitational force.
- Due to collapse, the center becomes hotter and hotter until nuclear fusion begins in the core.
- So the whole study of star formation is a multi stage event.
- A through several stages of evolution till it emerges itself as a main-sequence star

A Tale of Two Forces:

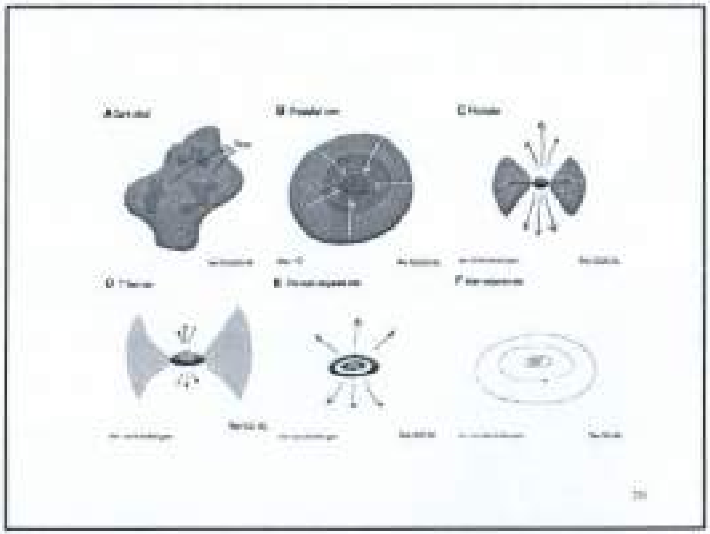
Pressure vs Gravity

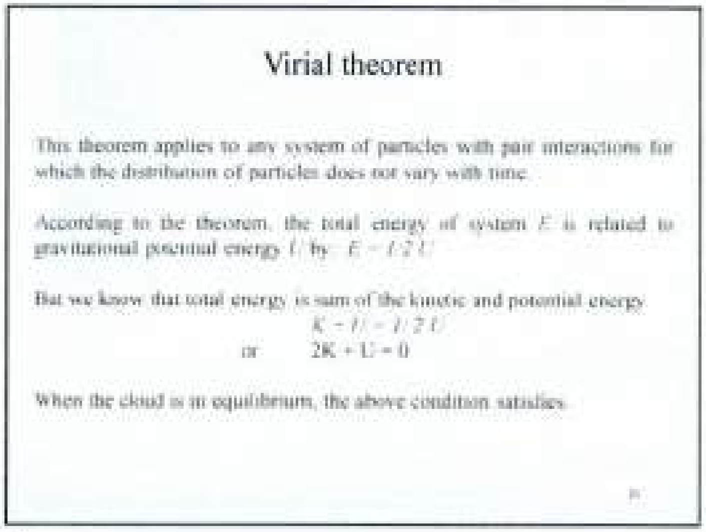


- Initially the interstellar cloud starts to contract
- The cloud starts to fragment into smaller pieces due to contraction
- The fragmented pieces form many stars

Does the fragmentation will continue forever? NO

A single fragmented clump also pass multiple stages till it appear as a main-sequence star





Virial theorem

This theorem applies to any system of particles with pair interactions for which the distribution of particles does not vary with time.

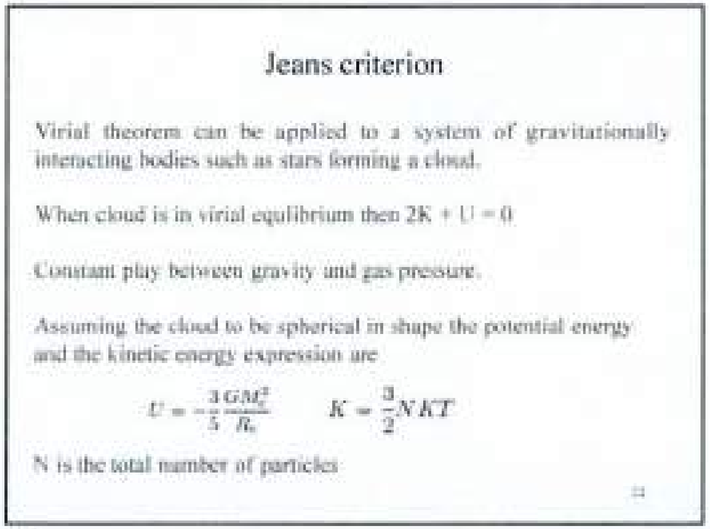
According to the theorem, the total energy of system E is related to gravitational potential energy U by $E = U/2$

But we know that total energy is sum of the kinetic and potential energy

$$K + U = U/2$$

or $$2K + U = 0$$

When the cloud is in equilibrium, the above condition satisfies.



Jeans criterion

Virial theorem can be applied to a system of gravitationally interacting bodies such as stars forming a cloud.

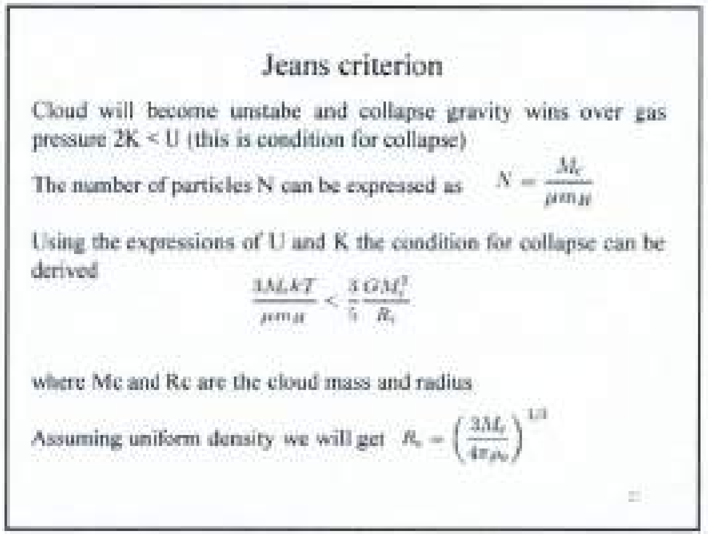
When cloud is in virial equilibrium then 2K + U = 0

Constant play between gravity and gas pressure.

Assuming the cloud to be spherical in shape the potential energy and the kinetic energy expression are

$$U = -\frac{3}{5}\frac{GM_c^2}{R_c} \qquad K = \frac{3}{2}NKT$$

N is the total number of particles



Jeans criterion

Cloud will become unstabe and collapse gravity wins over gas pressure 2K < U (this is condition for collapse)

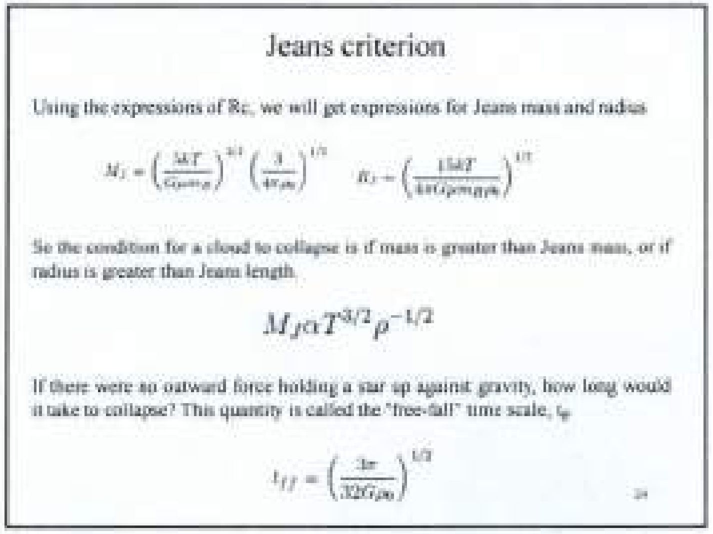
The number of particles N can be expressed as $N = \frac{M_c}{\mu m_H}$

Using the expressions of U and K the condition for collapse can be derived

$$\frac{3M_c kT}{\mu m_H} < \frac{3}{5}\frac{GM_c^2}{R_c}$$

where Mc and Rc are the cloud mass and radius

Assuming uniform density we will get $R_c = \left(\frac{3M_c}{4\pi\rho_0}\right)^{1/3}$



Jeans criterion

Using the expressions of Rc, we will get expressions for Jeans mass and radius

$$M_J = \left(\frac{5kT}{G\mu m_H}\right)^{3/2}\left(\frac{3}{4\pi\rho_0}\right)^{1/2} \qquad R_J = \left(\frac{15kT}{4\pi G\mu m_H\rho_0}\right)^{1/2}$$

So the condition for a cloud to collapse is if mass is greater than Jeans mass, or if radius is greater than Jeans length.

$$M_J \alpha T^{3/2}\rho^{-1/2}$$

If there were no outward force holding a star up against gravity, how long would it take to collapse? This quantity is called the "free-fall" time scale, t_{ff}

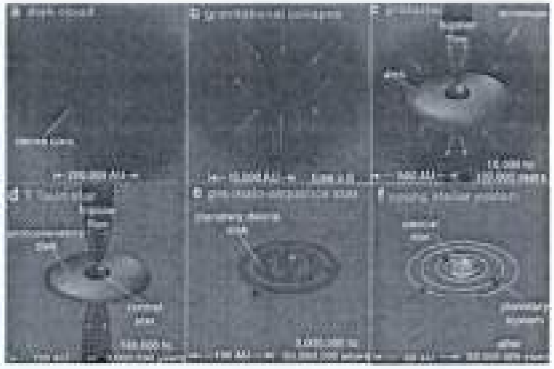
$$t_{ff} = \left(\frac{3\pi}{32G\rho_0}\right)^{1/2}$$

- During the collapse, ρ increases. As long as the density still remains adequately low for the cloud to be transparent, the released thermal energy is radiated into the universe and the temperature remains approximately constant.

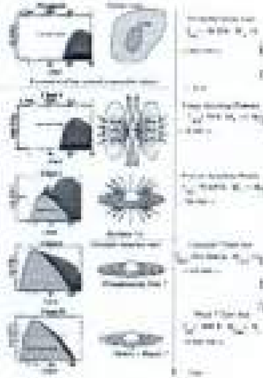
$$M_J \alpha T^{3/2} \rho^{-1/2}$$

- This suggests, a decrease of the Jeans mass. In particular, sub-sections of the cloud suddenly surpass their own Jeans limit and start collapsing on their own. As also t_{ff} is smaller for higher densities, these sub-collapses proceed faster. This clearly leads to fragmentation.
- But how long this fragmentation will continue?
- This continue till the cloud is optically thin. Once the cloud becomes thick enough and do not radiate energy and keep the system isothermal.
- This change from isothermal to adiabatic which will stop further fragmentation.

STAR'S BIRTH



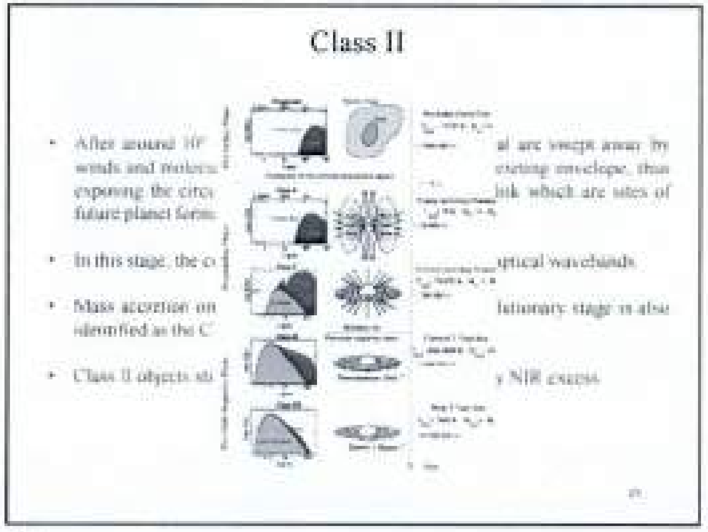
Class 0



- This class compri
of the core is muc
tostars. Here, the mass
nvelope
- Class 0 sources di
momentum, thus
help to remove angular
- These outflows
features are possil
herical and disk-like
- Class 0 objects a
temperature betw
millimetre (sub-
wavelengths.
ingle blackbodies with
nfrared (FIR) or sub-
tem visible at these

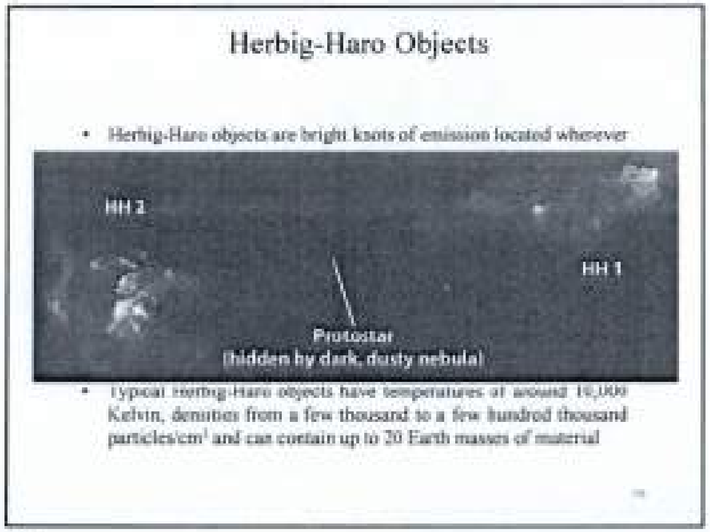
Class I

- As accretion con
moves to the FIR
d the peak of the SED
- In this evolution
circumstellar ac
central object is
emission suffers
ling material to form a
umstellar object. The
dusty envelope. So, its
- The SEDs of
temperature 30
second with temp
components – one of
eting envelope and the
nating from the disk
- Observationally,
in this phase
- During this stag
(MIR) wavelength
FIR and mid-infrared



Class II

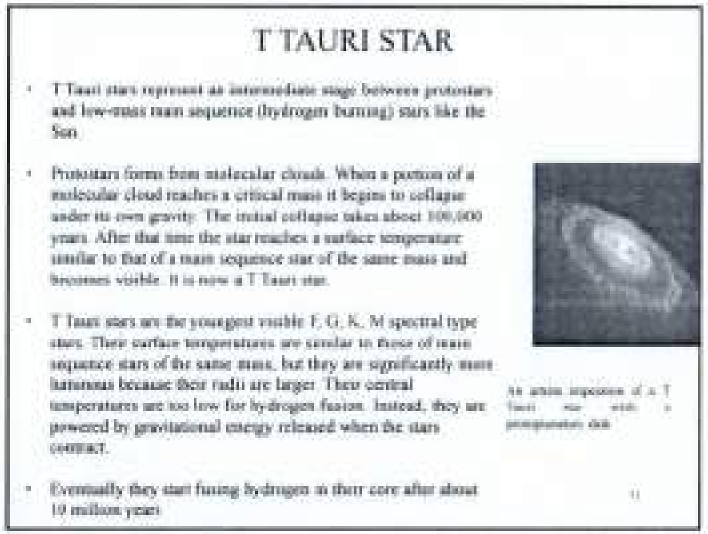
- After around 10 al are swept away by winds and molecu existing envelope, thus exposing the circ isk which are sites of future planet form
- In this stage, the c optical wavebands
- Mass accretion on tationary stage is also identified as the C
- Class II objects sh y NIR excess



Herbig-Haro Objects

- Herbig-Haro objects are bright knots of emission located wherever

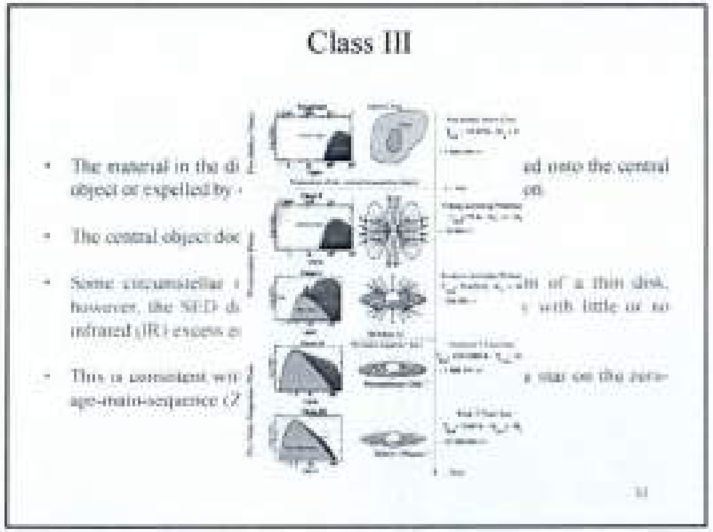
- Typical Herbig-Haro objects have temperatures of around 10,000 Kelvin, densities from a few thousand to a few hundred thousand particles/cm³ and can contain up to 20 Earth masses of material



T TAURI STAR

- T Tauri stars represent an intermediate stage between protostars and low-mass main sequence (hydrogen burning) stars like the Sun.
- Protostars forms from molecular clouds. When a portion of a molecular cloud reaches a critical mass it begins to collapse under its own gravity. The initial collapse takes about 100,000 years. After that time the star reaches a surface temperature similar to that of a main sequence star of the same mass and becomes visible. It is now a T Tauri star.
- T Tauri stars are the youngest visible F, G, K, M spectral type stars. Their surface temperatures are similar to those of main sequence stars of the same mass, but they are significantly more luminous because their radii are larger. Their central temperatures are too low for hydrogen fusion. Instead, they are powered by gravitational energy released when the stars contract.
- Eventually they start fusing hydrogen in their core after about 10 million years

An artistic impression of a T Tauri star with a protoplanetary disk



Class III

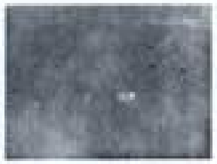
- The material in the di ed onto the central object or expelled by on
- The central object doe
- Some circumstellar ent of a thin disk, however, the SED di with little or no infrared (IR) excess a
- This is consistent wit a star on the zero-age-main-sequence (Z

PROTOSTAR

- Clouds continue to collapse as long as the gravitational potential energy is eliminated
- During the collapse, the density of the cloud increases toward the center and thus the middle region becomes optically opaque first.
- Particles fall towards the centre of the sphere and the kinetic energy increases. The kinetic energy of a group of particles is the thermal kinetic energy, or temperature, of the cloud. The more the cloud contracts the more the temperature increases.
- When the temperature is large enough so that the gas is hot enough for the internal pressure to support the cloud against further gravitational collapse and at this point the cloud is known as PROTOSTAR.

PROTOPLANETARY DISK

- A protoplanetary disk is a rotating circumstellar disk of dense gas surrounding a young newly formed T Tauri star
- The protoplanetary disk may be considered an accretion disc because gaseous material may be falling from the inner edge of the disk onto the surface of the star.
- As the collapsing cloud, called a solar nebula, becomes denser, random gas motions originally present in the cloud average out in favor of the direction of the nebula's net angular momentum. Conservation of angular momentum causes the rotation to increase as the nebula radius decreases. This rotation causes the cloud to flatten out—much like forming a flat pizza out of dough—and take the form of a disk, the protoplanetary disk.

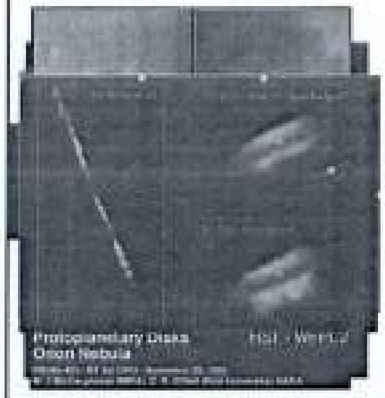


A protoplanetary disk in the Orion Nebula

WHAT HAPPENS AFTER THIS ?

- If the ball of gas formed does not have enough mass i.e. not enough atoms have been collected at the centre then it remains glowing dimly for the rest of its life also known as BROWN DWARF
- The centre of the ball of gas is the densest and the hottest region and If the temperature reaches about 15 million degree Celsius then pressure becomes very high and then it starts fusing hydrogen and it is said that star's true life starts here
- Once fusion starts star becomes a MAIN SEQUENCE STAR

Observational Evidence



- O-B Associations (clusters of massive stars associated with nearby molecular clouds)
- Young stellar objects (YSOs) with large enshrouding nebulae and thick disks
- More evolved objects with proto-stellar cores and proto-planetary disks
- Nearby objects seen with high resolution millimeter radio emission can pierce the dust and see the inner detail
- Gaps in the disk are likely regions where a new planet is forming
- In some objects, the strong magnetic fields that align with the poles of the new star can be seen to cause "jets" of molecules

Evolution of a star on HR diagram

Hayashi tracks

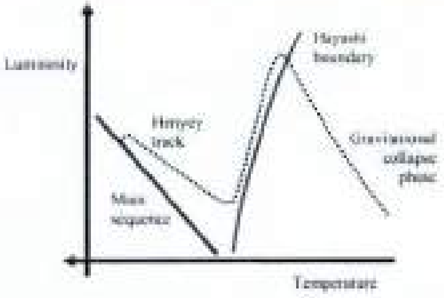
The HR Diagram

- HR diagram

Henyey tracks

Contraction at nearly constant T stops when the star develops a radiative core

The star moves to the MS along nearly horizontal paths in the HR diagram



How stars produce energy?

Stars produce energy by nuclear fusion reactions

Nuclear Fission: The process of splitting an atomic nucleus is called *nuclear fission*. Our nuclear power plants generate power by splitting large nuclei such as uranium or plutonium into smaller ones.

Nuclear Fusion: The process of combining (or fusing) two small atoms into a larger one

41

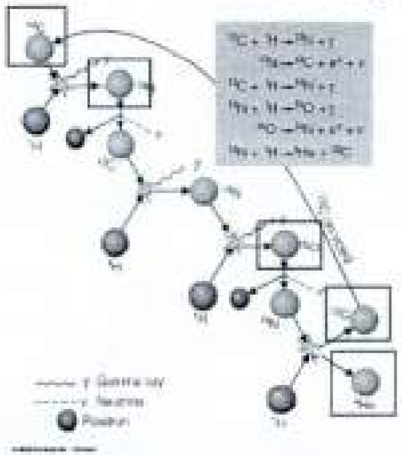
Proton-Proton Chain

Proton-Proton chain fuses four protons into one helium

In the sun, energy production happens primarily through the proton-proton (P-P) chain reaction.

42

The CNO Cycle

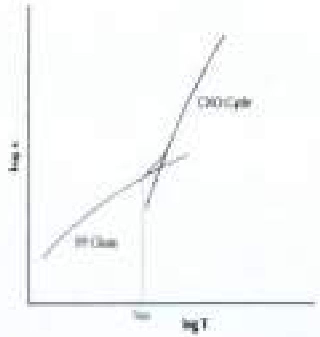


Happens in stars > 1.1 M

More efficient that the P-P chain.

Requires high T (>16 million K)

43



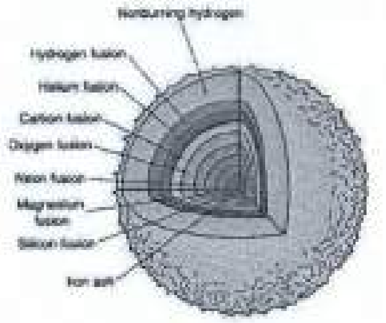
44

Small stars: The smallest stars only convert hydrogen into helium.

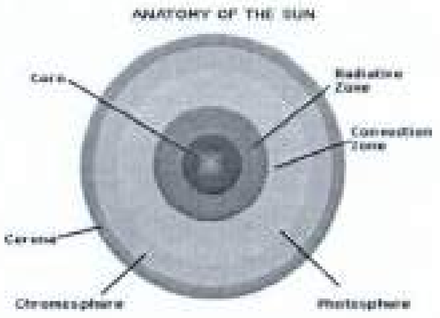
Medium-sized stars (like our Sun): Late in their lives, when the hydrogen becomes depleted, stars like our Sun can convert helium into oxygen and carbon.

Massive stars (greater than five times the mass of the Sun): When their hydrogen becomes depleted, high mass stars convert helium atoms into carbon and oxygen, followed by the fusion of carbon and oxygen into neon, sodium, magnesium, sulfur and silicon. Later reactions transform these elements into calcium, iron, nickel, chromium, copper and others.

Inside structure of stars



Inside structure of stars



Time-scales

Kelvin-Helmholtz time-scale: If a massive body gets smaller, it releases gravitational potential energy, in this case in the form of heat. Time taken to release all the energy is called t_{KH} and expressed as

$$t_{KH} = U/L$$

where U is the gravitational potential energy and L is the luminosity

For Sun the gravitational potential energy is 4×10^{48} erg and the luminosity is 3.86×10^{33} erg/sec

Hence for Sun $t_{KH} = 30$ Myr

Time-scales

Dynamical time scale

Measure of the time scale on which a star would expand or contract if the balance between pressure gradients and gravity was suddenly disrupted (same as free-fall time scale)

$$t_{dyn} = \frac{R}{v_{esc}}$$

Escape velocity from the surface of the star: $v_{esc} = \sqrt{\frac{2GM}{R}}$

So the dynamical time becomes $t_{dyn} = \sqrt{\frac{R^3}{2GM}}$

For Sun $t_{dyn} \sim 1100$ sec

Time-scales

Nuclear time scale

Time scale on which the star will exhaust its supply of nuclear fuel if it keeps burning it at the current rate

Energy release from fusing one gram of hydrogen to helium is 6×10^{18} erg

$$t_{nuc} = \frac{qXM \times 6 \times 10^{18} \mathrm{erg\,gm^{-1}}}{L}$$

X is the mass fraction of hydrogen initially present (X~0.7)
q is the fraction of fuel available to burn in the core (q~0.1)

For Sun the nuclear time-scale is $t_{nuc} \sim 7 \times 10^9$yr

This is reasonable estimate of the main-sequence lifetime of the Sun.

Time-scales

Dynamical time scale: Before become protostar

Kelvin-Helmholtz time-scale: Pre-main sequence life-time

Nuclear time scale: After star become main-sequence

$$t_{dyn} < t_{KH} < t_{nuc}$$

Stellar Mass Limits

Radiation pressure
vs
Gravity

Radiation:

- Luminosity L
- Spherically symmetric emission
- Energy flux at distance r: $L/4\pi r^2$
- Each photon has momentum $p=E/c$
- Momentum flux: $L/4\pi c r^2$

53

Eddington Limit

If the source is surrounded by gas with opacity k, then in traveling a distance ds the fraction of radiation absorbed is
$dI/I = -k\rho ds$

k is basically the fraction of radiation absorbed by unit column density of gas

Force exerted by radiation on that gas can be given as $f_{rad} = \dfrac{\kappa L}{4\pi c r^2}$

Force due to gravity on that gas (unit mass): $f_{grav} = \dfrac{GM}{r^2}$

54

Eddington Limit

Radiation pressure balances gravity when $f_{rad} = f_{grav}$

This will give $L = \dfrac{4\pi c G M}{\kappa}$

If L is larger than this value the pressure due to radiation exceeds the gravitational force at all radii, and gas will be blown away

Critical luminosity is called the Eddington limit. Depends upon:
- the mass of the star
- the opacity of the gas surrounding the star / source

55

Upper mass limit of star

A rough formula for the luminosity of very massive stars immediately after formation is:

$$\frac{L}{L_{sun}} \approx 1.2 \times 10^5 \left(\frac{M}{30 M_{sun}}\right)^{2.4}$$

Using M sun $= 1.989 \times 10^{33}$ g and L sun $= 3.9 \times 10^{33}$ erg s^{-1}: $L = 1.6 \times 10^{-45} M^{2.4}$ erg s^{-1} (with M in grams)

Compare with formula for Eddington limit: $L_{Edd} = 6.3 \times 10^4 M$ erg s^{-1}
$L = L_{Edd}$ for $M = 2.6 \times 10^{35}$ g ~ 130 Solar masses

Radiation pressure is an important effect for massive stars

56

Upper Limit on a Star's Mass

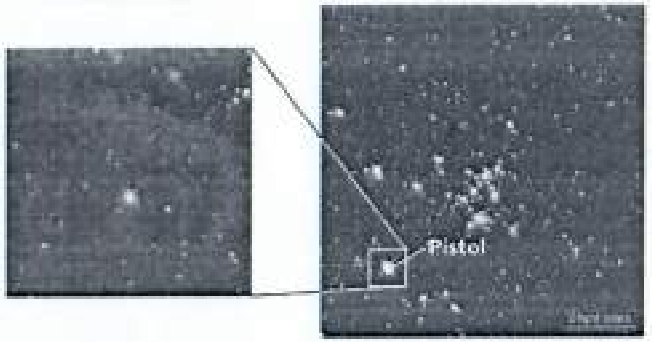
- Photons exert a slight amount of pressure when they strike matter
- Very massive stars are so luminous that the collective pressure of photons drives their matter into space
- Models of stars suggest that radiation pressure limits how massive a star can be without blowing itself apart

57

NGC 3603

58

200 solar mass star



59

Lower Limit on a Star's Mass

- Fusion will not begin in a contracting cloud if some sort of force stops contraction before the core temperature rises above 10^7 K.
- Thermal pressure cannot stop contraction because the star is constantly losing thermal energy from its surface through radiation.
- Is there another form of pressure that can stop contraction?

Degeneracy Pressure vs thermal pressure

Laws of quantum mechanics prohibit two electrons from occupying the same state in the same place

Depends on heat content The main form of pressure in most stars

60

Brown Dwarfs

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Stellar Mass Limits

Do Stars form alone?

Star Clusters

As gas clouds collapse, they often form stars in clusters ranging from tens of stars to thousands of stars. Every star in a cluster formed from the same cloud, so they have the same metal mass fraction.

There are two types. **Population II clusters (generically called "globular" clusters)** tend to have older, more metal poor stars.

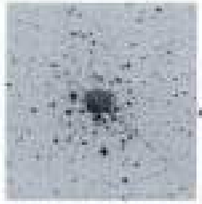
Population I clusters ("galactic" or "open" clusters) tend to be younger, with more metals.

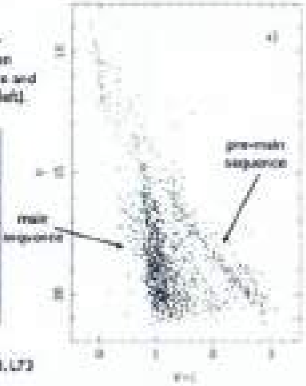
Examples:

M13 Globular cluster: Thousands of stars, age of 14 billion years.

Pleiades Galactic cluster: Many stars, dominated by luminous blue stars, formed within the last 100 Myr.

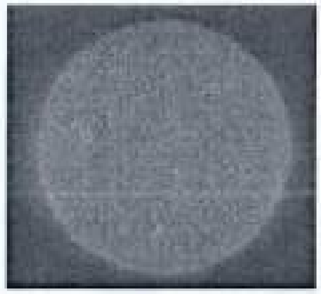
Color-magnitude diagram for NGC 2362, a very young open cluster. Shows Main sequence and pre-main sequence stars (on left).

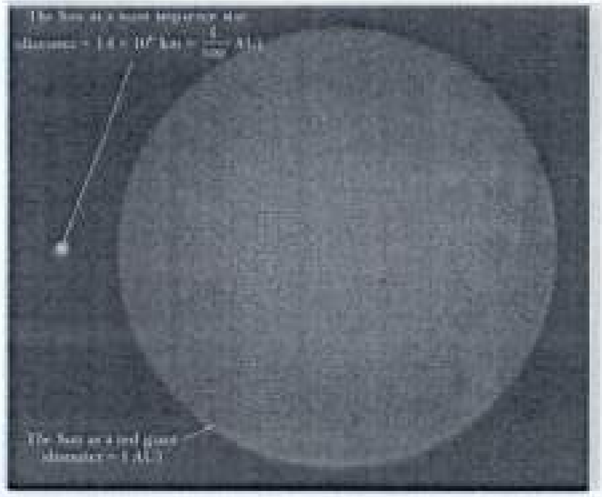


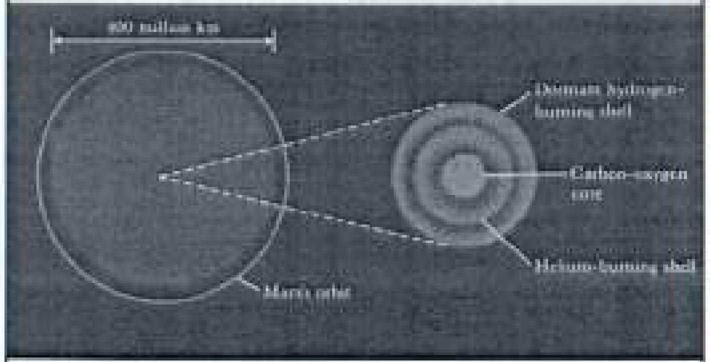


Moitinho et al. 2001, ApJ, 563, L73

When the hydrogen supply in the core begins to run out, the core becomes unstable and contracts; the outer shell of the star which is still mostly hydrogen, starts to expand. As it expands, it cools and glows red; it has now reached the Red Giant Phase.





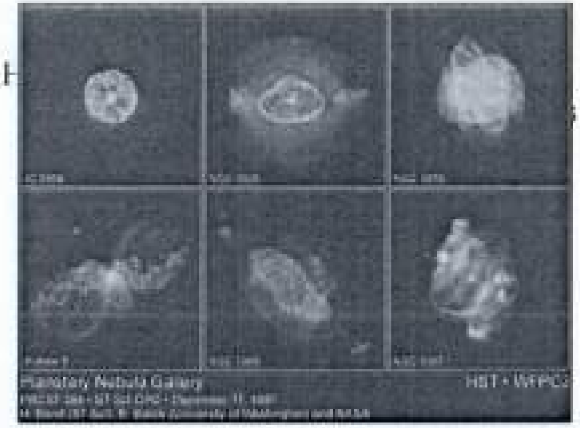


Mass of Star Determines Fate

- All stars evolve the same way up to the Red Giant Phase. The amount of mass a star has determines which of the following life cycle paths it will take after the Red Giant Phase.

- Small Stars
- Massive Stars

Fate of Small Stars



Gravity causes the last of the star's matter to collapse inward and compact into an extremely dense White Dwarf core that glows with a white hot light.

Once all of a white dwarf's energy is gone, it no longer emits light, reaching the Black Dwarf phase in which it will forever remain. A completely dead star that is dark and cold.

This is the end of a small star's life.

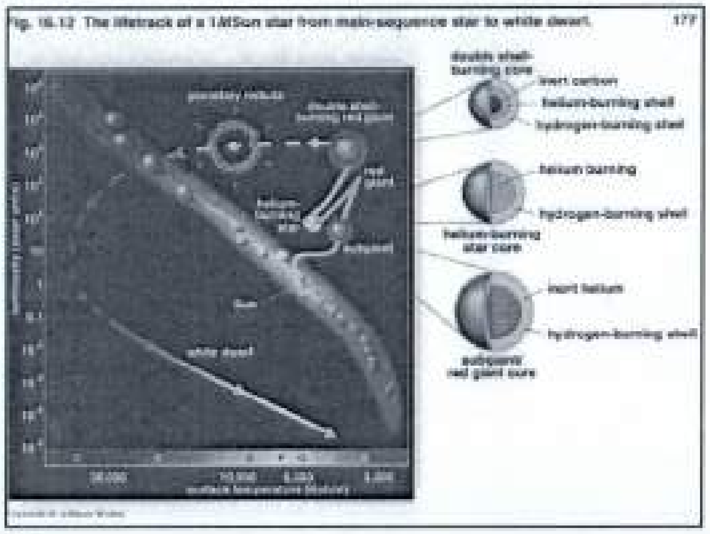
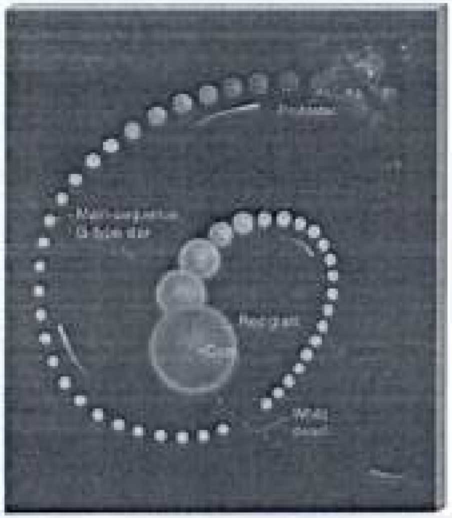


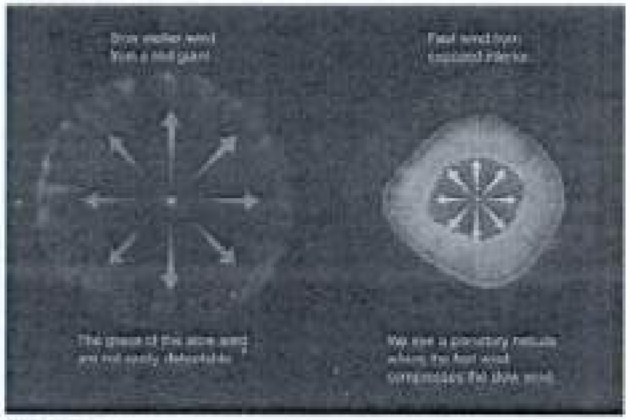
Fig. 18.12 The lifetrack of a 1MSun star from main-sequence star to white dwarf.

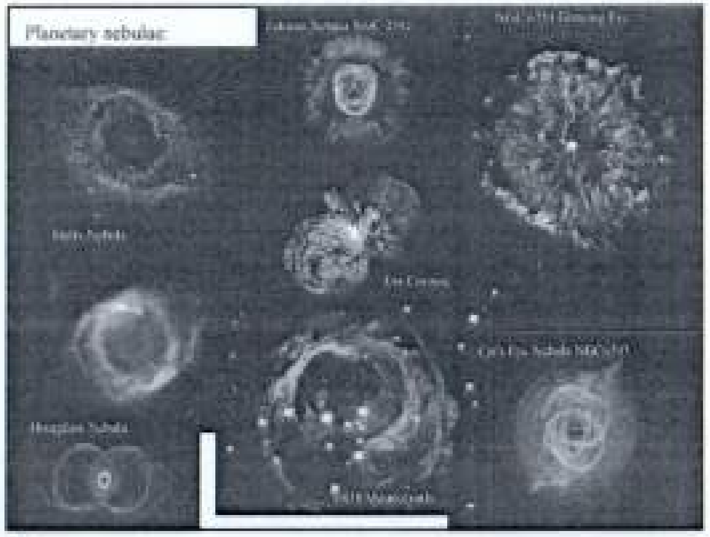


Maximum white dwarf mass

- Electron degeneracy cannot support a white dwarf heavier than 1.4 solar masses
- This is the "Chandrasekhar limit"
- Won Chandrasekhar the 1983 Nobel prize in Physics

Planetary nebulae





Planetary nebulae

Fate of a Massive Star

In the next million years, a series of nuclear reactions occur forming a carbon atoms from the fusion of helium atoms; gravity continues to pull carbon atoms together as the temperature increases forming oxygen, nitrogen, and eventually iron. GETTING HEAVY!

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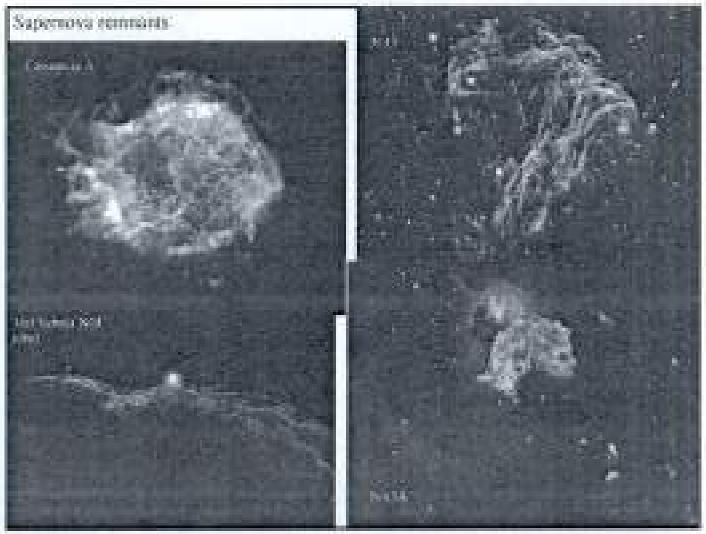
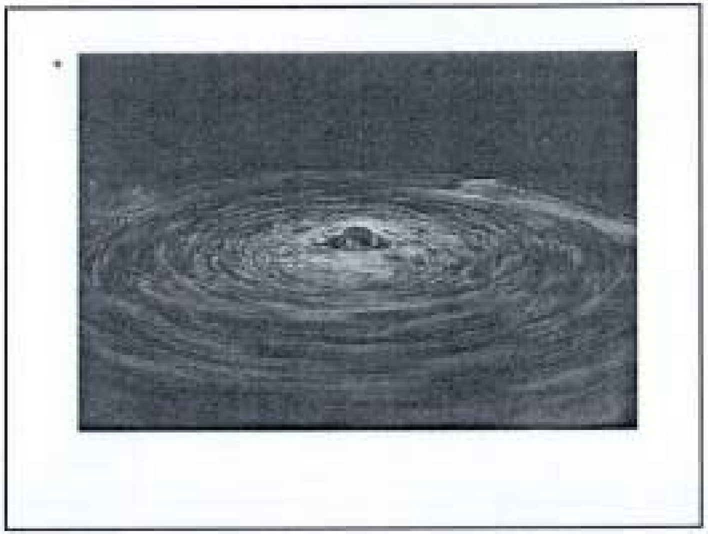
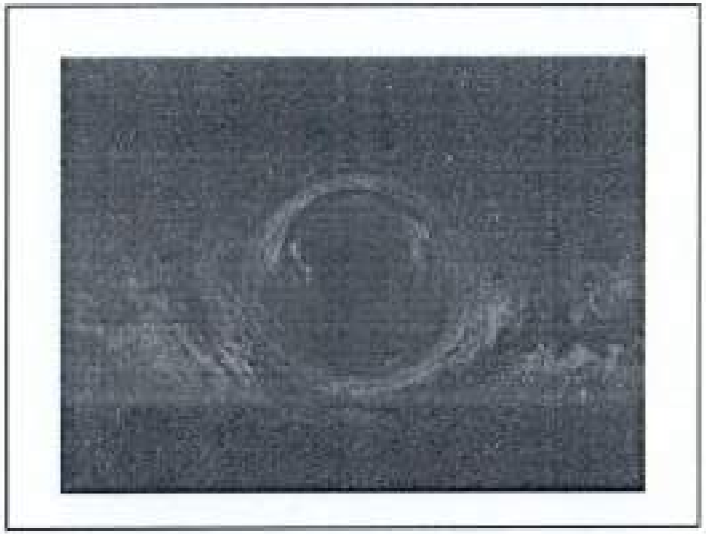


Supernova remnants

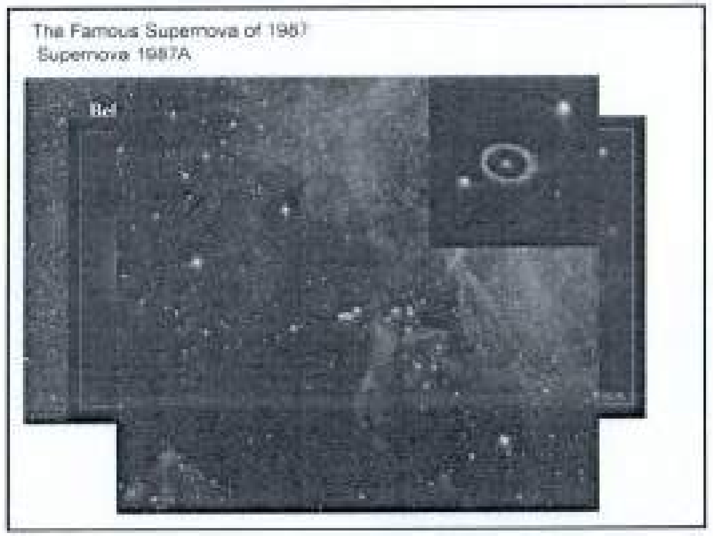
81



82

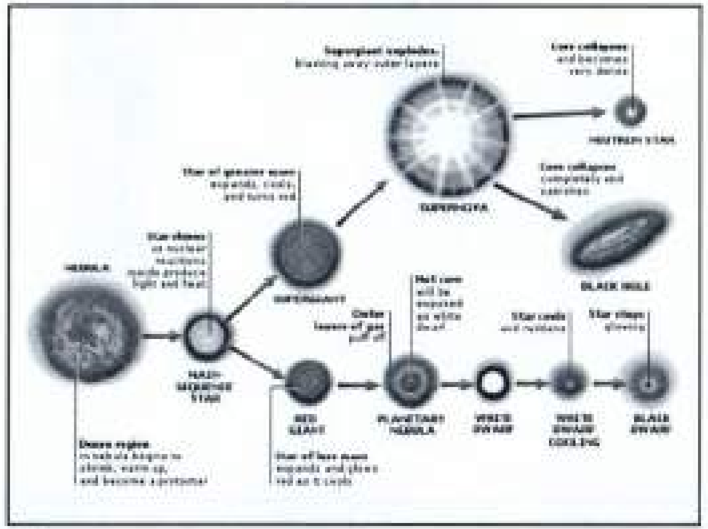


83



The Famous Supernova of 1987
Supernova 1987A

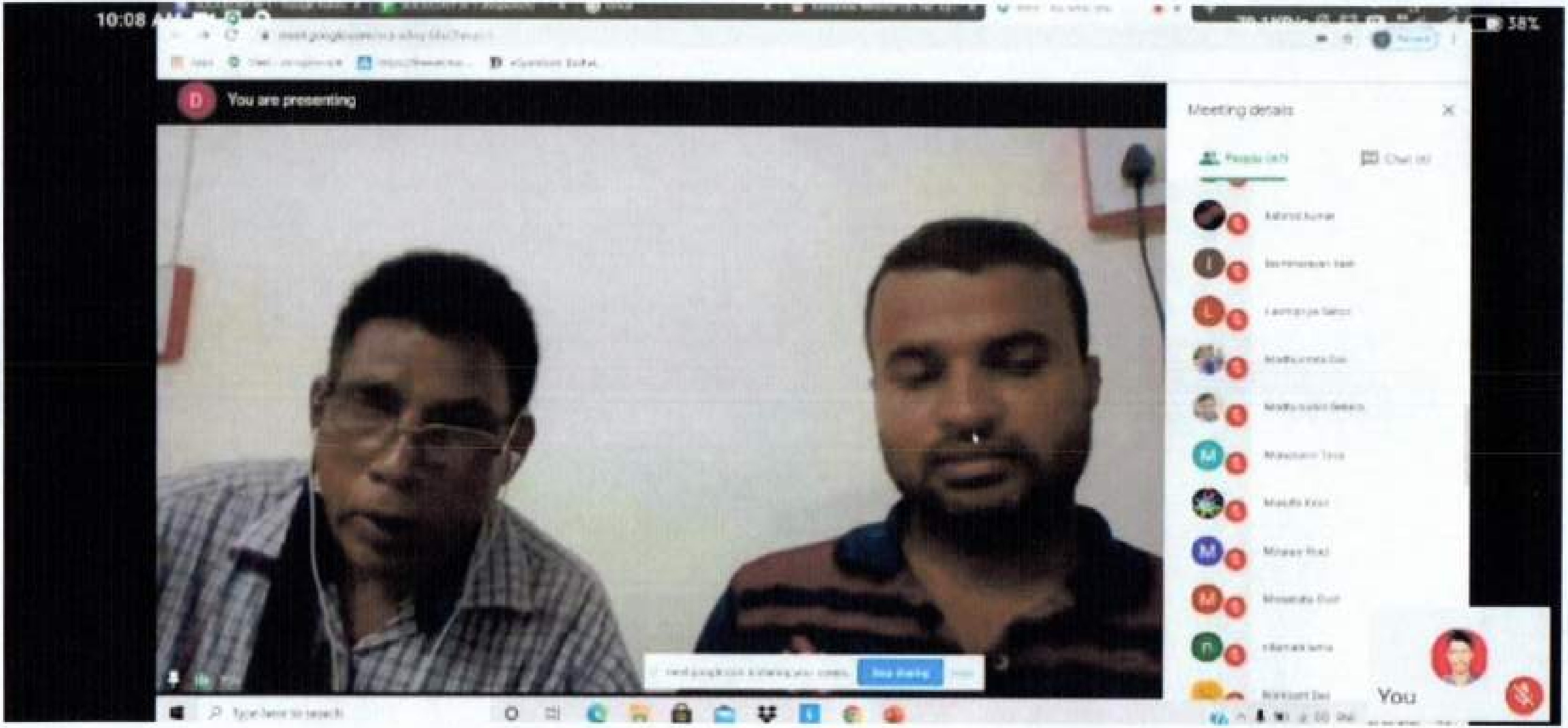
84


NEBULA
MAIN-SEQUENCE STAR
SUPERGIANT
SUPERNOVA
NEUTRON STAR
BLACK HOLE
RED GIANT
PLANETARY NEBULA
WHITE DWARF
WHITE DWARF COOLING
BLACK DWARF

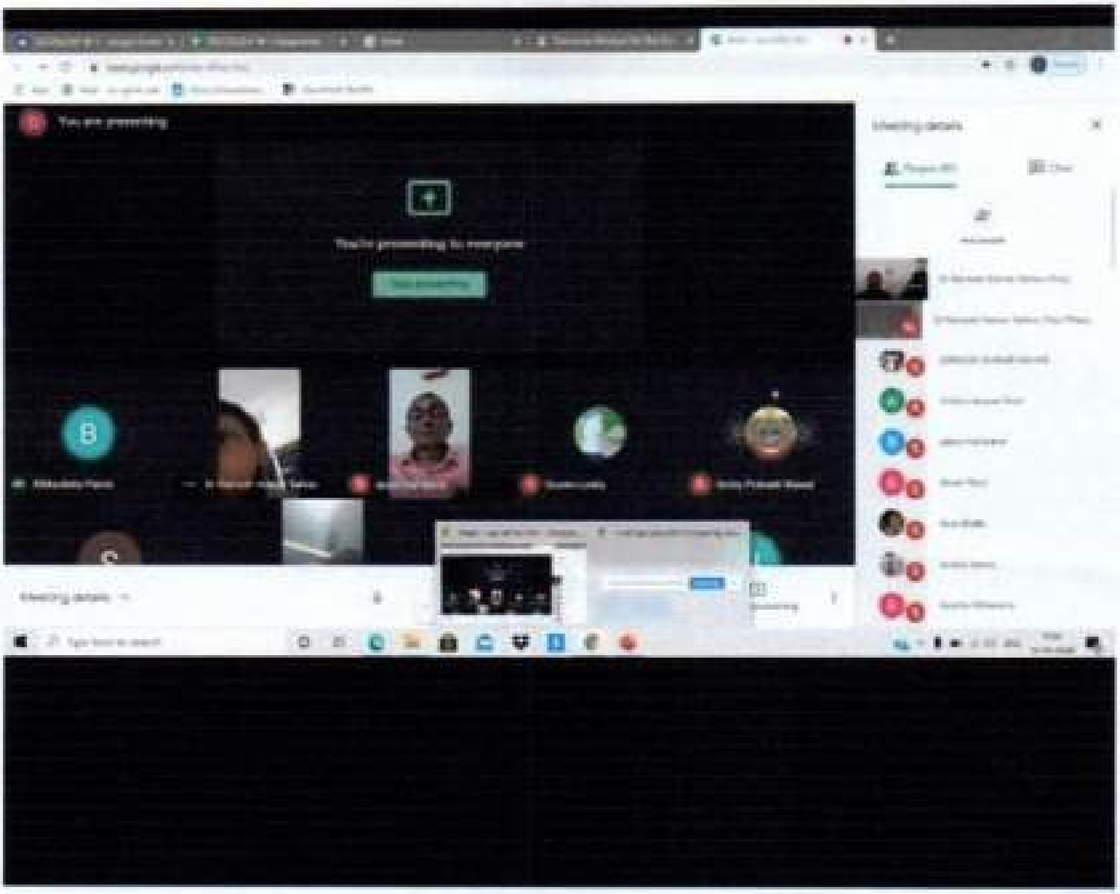
85

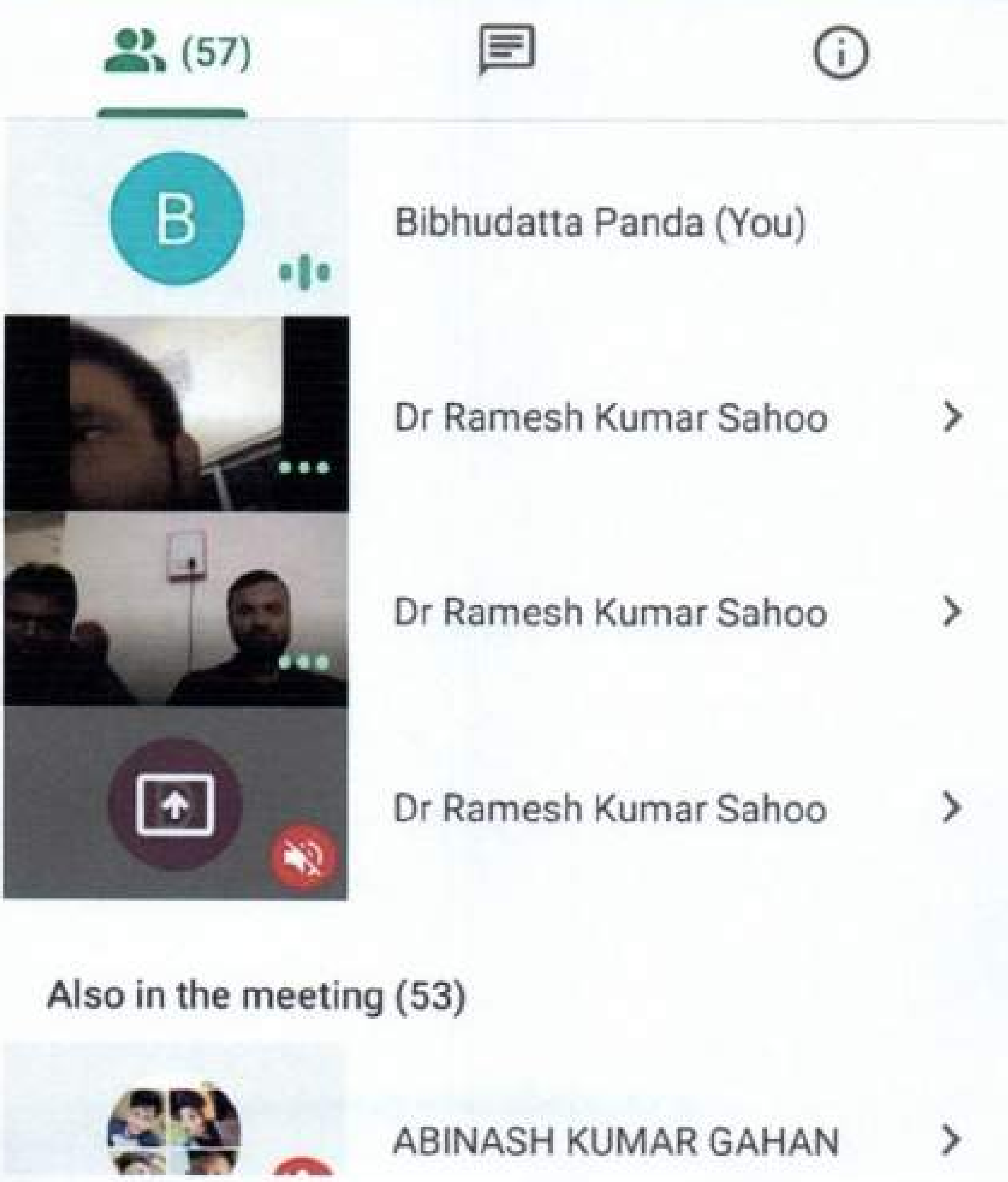

Thank you!

86


10:08
38%
D
You are presenting
Meeting details
You


10:07
38%
D
You are presenting
Meeting details
You





Bibhudatta Panda (You)

Dr Ramesh Kumar Sahoo

Dr Ramesh Kumar Sahoo

Dr Ramesh Kumar Sahoo

Also in the meeting (53)

ABINASH KUMAR GAHAN

Timestamp	Email Address	FULL NAME	E OF COLLEGE/ INSTITU	PROFESSION	CLASS & ROLL NO.) Please	MOBILE NO.
9-8-2020 13:49:18	bkswain@gcekbpatna.ac.in	Dr. B. K SWAIN	Gcek	FACULTY	Na	9937708687
9-8-2020 14:05:00	prajnanandarath@gmail.com	PRAJNANANDA RATH	Pattamundai degree colleg	STUDENT	CLASS- +3 3rd year science(p	7608830889
9-8-2020 14:06:21	arabindapandab@gmail.com	ARABINDA PANDAB	PATTAMUNDAI COLLEGI	FACULTY	NA	9937254024
9-8-2020 14:08:59	www.satyajitmahalik527@gmail.com	Satyajit mahalik	Pattamundai degree colleg	STUDENT	Class - +3 3rd year	7735551855
9-8-2020 14:13:09	drpksamal1963@gmail.com	Dr. Pramod Kumar Samal	Pattamundai College	FACULTY	NA	9337143523
9-8-2020 14:15:55	dashp496@gmail.com	PRADEEP KUMAR DASH	Pattamundai Degree Colle	STUDENT	+3 3rd year (5th semester), D	+916370541023
9-8-2020 14:16:16	www.suvamlenka1234@gmail.com	SUVAM LENKA	Pattamundai college, patta	STUDENT	+3 3rd year student ,Roll no -	7325899029
9-8-2020 14:30:15	bibekbehuria272@gmail.com	Bibek Behuria	Pattamundai degree colleg	STUDENT	+3rd (5th semester) roll no_Bs	6370668109
9-8-2020 14:45:24	deepikadash001@gmail.com	Dipika dash	Pattamundai degree colleg	STUDENT	Class- +3 3rd year and roll no.	7325825393
9-8-2020 15:04:09	bibhudattapanda34@gmail.com	BIBHUDATTA PANDA	Pattamundai College, Patt	STUDENT	Cls-+3 3rd year, Roll no-BS18	9777028363
9-8-2020 15:05:12	dparida1965@gmail.com	DR DUSHASAN PARIDA	PATTAMUNDAI COLLEGI	FACULTY	NA	9853165455
9-8-2020 15:08:25	priyaranjanm005@gmail.com	PRIYARANJAN MOHANTY	Rajnagar college, Kendrap	FACULTY	NA	8917621144
9-8-2020 15:26:23	baikunthroul1@gmail.com	Baikunth charan Roul	Pattamundai College	FACULTY	NA	9337127295
9-8-2020 15:51:47	excellentsaroja@gmail.com	Sarojakanta Nayak	Pattamundai College	FACULTY	NA	9583371671
9-8-2020 16:07:17	ranjan775819@gmail.com	RANJAN KUMAR BEHURA	PATTAMUNDAI COLLEGI	FACULTY	NA	9668830365
9-8-2020 16:14:37	padhibasudev146@gmail.com	BASUDEV PADHI	Pattamundai degree Colle	STUDENT	Class-+3 2nd year physical sc	9668440946
9-8-2020 16:53:57	pravatkesharipanda@gmail.com	PRAVAT KESHARI PANDA	PATTAMUNDAI COLLEGI	STUDENT	+3 Physics hons & Roll/Regd	9090715969
9-8-2020 17:08:36	subhasmitarout3333@gmail.com	Subhasmita Rout	Pattamundai degree colleg	STUDENT	Bs-17-044 , +3 3rd year scien	7377299648
9-8-2020 17:50:31	deepalisahoo62511@gmail.com	Deepaali Sahoo	Pattamundai collage, Patta	STUDENT	+3 6th semester ,Roll no. Bsc-	7894820597
9-8-2020 17:54:21	sarangibijayalaxmi100@gmail.com	Bijayalaxmi sarangi	Pattamundai degree colleg	STUDENT	BS17-129	8917509543
9-8-2020 18:05:24	srinibash19sahoo@gmail.com	Srinibash sahoo	Pattamundai degree colleg	STUDENT	+3 Final year(science , Physic	8917398157
9-8-2020 18:24:53	laxmipriya20111@gmail.com	Laxmipriya sahoo	Pattamundai college, patta	STUDENT	Roll no.-BS17-032 ,Class- +3	8328812331
9-8-2020 18:28:49	radharanidas27@gmail.com	Radharani Das	Centurion University of tec	STUDENT	Msc, roll no-180705120006	8144190551
9-8-2020 18:30:30	jenaminati@gamail.com	Minati jena	Au degree college ,Aul	STUDENT	+3 3rd yr ,roll-BS17085	7684894292
9-8-2020 18:40:00	behurasukalyani@gmail.com	Sukalyani behura	Pattamundai degree colleg	STUDENT	(Science, physics hons, Bs-17	8114328570
9-8-2020 18:41:13	gudicuty567@gmail.com	Jajnyasenee Das	Pattamundai degree colleg	STUDENT	17002010078	7750887015
9-8-2020 18:44:40	2000kshirodkumar@gmail.com	khirod kumar sethi	pattamundai degree collag	STUDENT	class_+3final year(scince phy	9178096187
9-8-2020 18:47:14	ashisrout541@gmail.com	Ashis Rout	brahmani college dandisah	STUDENT	Bsc-17-078, +3 3rd year scien	7653927422
9-8-2020 18:57:34	skrashal450@gmail.com	Sandeep Kumar Behera	Pattamundai degree colleg	STUDENT	Bs 17 079	9123792694
9-8-2020 19:08:41	tarakantamaharana@gmail.com	Tarakanta maharana	Kps school,kendarapara	FACULTY	NA	9040992583
9-8-2020 19:10:20	nibeditapatra161@gmail.com	Nibedita Patra	Pattamundai degree colleg	STUDENT	+3 3rd year, BS17-120	7377758748
9-8-2020 19:12:19	soubhagyaallinone@gmail.com	Aditya narayan rout	Pattamundai degree colleg	STUDENT	+3 2nd year ,BS19-115	7751041659
9-8-2020 19:12:36	silpasilpa519@gmail.com	Silpa Rani Das	Pattamundai college,Patta	STUDENT	BS17-150	9556386618
9-8-2020 19:19:49	pujasatapathy6@gmail.com	Puja satapathy	Pattamundai degree colleg	STUDENT	Class-+3 3rd year,Roll no-BS1	9938009631

9-8-2020 19:24:08	abinashgahan317@gmail.com	Abinash Kumar Gahan	Pattamundai college, patta	STUDENT	+3 3rd year, BS18-120	7681893549
9-8-2020 19:24:27	bulurani7894998324@gmail.com	Mirarani rout	Pattamundai degree colleg	STUDENT	+3 2nd year, BS19-090	7894998324
9-8-2020 19:59:19	diluniranjan@gmail.com	Niranjan Das	pattamundai degree colleg	STUDENT	BS 17 133	8917234911
9-9-2020 4:15:50	indumatir077@gmail.com	Indumati munda	Govt. autonomous college	STUDENT	Pg 1st yr	8249439505
9-9-2020 6:28:52	kalipadagiri64@gmail.com	Kalipada Giri	pattamundai degree colleg	STUDENT	+3 3rd year ,BS18-034	8114716537
9-9-2020 7:30:55	saratchandradasenglish@gmail.com	DR. SARAT CHANDRA DA	PATTAMUNDAI COLLEGI	FACULTY	NA	9776907778
9-9-2020 9:19:20	sujitsamal10january@gmail.com	Sujit Samal	Pattamundai college	STUDENT	+3 1st yr science	8658517380
9-9-2020 9:27:22	swagsrd@gmail.com	Swagat ranjan dash	Pattamundai college	STUDENT	Bs 18 009	8144570330
9-9-2020 9:33:52	chinmayaprasadbarik@gmail.com	CHINMAYA Prasad barik	Pattamundai degree colleg	STUDENT	Class-+3 third year science (pl	8249619984
9-9-2020 9:36:31	madhusudanbehera257@gmail.com	Madhusudan Behera	Pattamundai college, patta	STUDENT	+3 3rd year bsc , physics hon.	9348656306
9-9-2020 9:38:47	sahooswora j7@gmail.com	Sworaj Sahoo	Aul Degree College	STUDENT	+3 2 year , roll - Bs(p)19 - 088	6372775887
9-9-2020 9:49:19	soumyasonu304@gmail.com	SOUMYA RANJAN BEHER	PATTAMUNDAI COLLEGI	STUDENT	Bs_18_021	9348849906
9-9-2020 9:51:56	shraddhanjali33@gmail.com	Shraddhanjali samal	Pattamundai college	STUDENT	Bs-18-136	9348452613
9-9-2020 10:01:26	santoshmishra1084@gmail.com	Srutisudha Mishra	Pattamundai(degree)colleg	STUDENT	+3 2nd year. Rollno. -BS(P)19	9861073955
9-9-2020 10:02:47	asimanath430@gmail.com	Asima Nath	Pattamundai college, patta	STUDENT	+3 2nd year, BS-19-030	7978687983
9-9-2020 10:09:22	aparnamoharana495@gmail.com	Aparna Moharana	Pattamundai degree colleg	STUDENT	+3 3rd year Roll No-BS-18-132	7735658508
9-9-2020 10:10:19	ranjankumargahan746@gmail.com	RANJAN KUMAR GAHAN	Pattamundai college Patta	FACULTY	NA	7735355311
9-9-2020 10:18:15	roulakash5[illegible]9@gmail.com	Akash Rout	Pattamundai Junior Colleg	STUDENT	+3 2nd year. roll_47.	8114613133
9-9-2020 10:20:06	smrutirekhasniki@gmail.com	Smruti rekha Das	Pattamundai degree colleg	STUDENT	+3 2nd yr , Roll no BS-19 -105	7992916924
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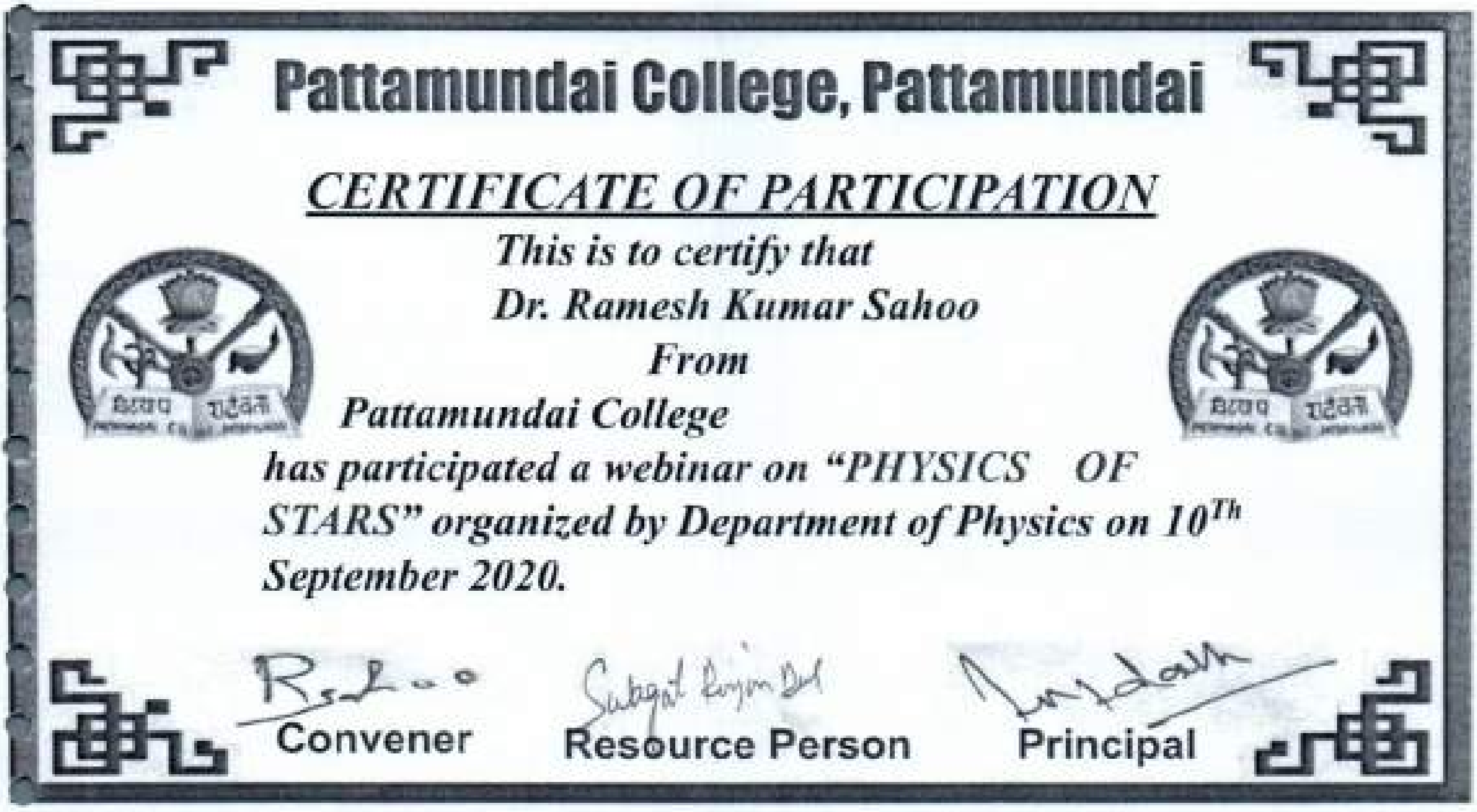
9-9-2020 10:52:30	ajayamaharana22@gmail.com	Ajaya kumar maharana	Pattamundai college	FACULTY	NA	8917509637
9-9-2020 11:00:16	puchanasir@gmail.com	Satyabrata Biswal	Pattamundai college,Patta	FACULTY	NA	9937195316
9-9-2020 11:07:30	nilamani.lenka00@gmail.com	DR NILAMANI LENKA	Pattamundai College	FACULTY	NA	9438329950
9-9-2020 13:47:21	dilipbhuyan1965@gmail.com	DILLIP KUMAR BHUYAN	Pattamundai Degree colle	FACULTY	NA	9437383989
9-9-2020 14:00:57	manasnayak2009@gmai.com	DR MANAS KUMAR NAYA	Pattamundai College	FACULTY	NA	8763776106
9-9-2020 14:20:26	ritkranjan@143gmail.com	Ritik ranjan patra	Pattamundai college pattai	STUDENT	BS19 067	7327003341
9-9-2020 16:12:46	sangitasubhasmitaroul@gmail.com	Sangita Subhasmita Roul	Utkal University	STUDENT	NA	6370747916
9-9-2020 16:25:06	nishikantdas83324@gmail.com	Nishikanta Das	Pattamundai college pattai	STUDENT	82	7751052296
9-9-2020 16:32:15	rakeshbehura75@gmail.com	Rakesh Kumar Behura	Pattamundai College	STUDENT	NA	9090757754
9-9-2020 17:29:12	sunandasahoo164@gmail.com	Sunanda sahoo	Pattamundai college, patta	STUDENT	Bs18 _88	7377115579
9-9-2020 17:48:03	khannousad6@gmail.com	Nousad khan	Pattamundai degree colleg	STUDENT	+3 3rd year .roll- BS 17-007	8117025015
9-9-2020 18:13:29	dolagobindapanda39@gmail.com	Amisha Panda	Pattamundai Degree Colle	STUDENT	+3 2nd year. Roll-BS(p)/19/19.	7853813201
9-9-2020 18:19:05	biswaranjansahoo658@gmail.com	BISWARANJAN SAHOO	PATTAMUNDAI COLLEGI	STUDENT	+3 3rd year and BS17-155	9078084241
9-9-2020 18:31:39	chinmaya454@gmail.com	Chinmaya Kumar Sahoo	Bhavan's center for comm	STUDENT	NA	9937245562

9-9-2020 18:36:36	sarojinijena61@gmail.com	Sarojinijena	Pattamundai dreeg college	STUDENT	Dpt- physics, roll no- BS 18- 0	9556316737
9-9-2020 19:28:37	priyadarshinidash2001@gmail.com	Priyadarshini Dash	Pattamundai college patta	STUDENT	+3 third year, BS-18-016	7077618247
9-9-2020 19:34:25	barsha336@gmail.com	Barsharani sahoo	Pattamundai college, patta	STUDENT	Cls-+3 3rd year, roll no-Bs 18	7735468703
9-9-2020 19:59:51	subhakantalenka789@gmail.com	Subhakanta Lenka	Pattamundai College, Patt	STUDENT	Class-3rd year.Roll no-BS17-1	9337769624
9-9-2020 20:07:33	nibeditanayak63@gmail.com	MRS NIBEDITA NAYAK	Pattamundai college	FACULTY	NA	9668725524
9-9-2020 20:30:38	monalishakunidash@gmail.com	MONALISHA DASH	Pattamundai college patta	STUDENT	+3 3rd year BS18_039	6370995348
9-9-2020 20:34:15	khatuarudranarayan@gmail.com	rudranarayan khatua	Dept. Of Physics, IIT(ISM)	STUDENT	2016dr0091	7274081929
9-9-2020 20:41:41	rogergunu18@gmail.com	Satya ranjan patra	Pattamundai college, patta	STUDENT	+3 3rd year 5th semi., BS-18-	9668256943
9-9-2020 20:45:45	99subhashreesubhasmita@gmail.com	Subhashree Subhasmita	Shishu Ananta Mahavidyal	STUDENT	+3 3rd year, Roll No. -121	9583583728
9-9-2020 21:33:30	manaswinitarai2020@gmail.com	MANASWINI TARAI	BRAHMANI COLLEGE , D	STUDENT	CLASS _POST THIRD YEAR	7751949097
9-9-2020 21:34:53	pujapandapallavi@gmail.com	PALLAVI PUJAPANDA	Vikram Dev autonomous c	FACULTY	NA	08342806848
9-9-2020 21:36:13	satyajitdas8591@gmail.com	SATYAJIT DAS	Pattamundai degree colleg	STUDENT	Bs-18-126	8480751642
9-9-2020 21:44:28	bhagyashreemohanty025@gmail.com	Bhagyashree Mohanty	Pattamundai college patta	STUDENT	+3 3rd year....Roll no._BS18_	8079709181
9-9-2020 21:44:51	jenapreetam08@gmail.com	Preetam jena	DEBARAY SAMARSINGH	STUDENT	CLASS: +3 3rd yr science,Roll	7325878794
9-9-2020 21:54:44	fahmidabadar786@gmail.com	Fahmida Badar	Sishuananta mahavidyalay	STUDENT	+3 third year,roll no-bs18-014	9777841292
9-9-2020 21:55:10	dasdinabandhu452@gmail.com	MADHUSMITA DAS	PATTAMUNDAI DEGREE	STUDENT	3rd year science (Chemistry)	9861342112
9-9-2020 21:55:45	swagatikadas871@gmail.com	SWAGATIKA DAS	Pattamundai degree colleg	STUDENT	Cls- +3 3rd year, R.N- BS-18-	9938970570
9-9-2020 22:01:30	jenapreetam08@gmail.com	PREETAM JENA	Aul Degree College, Kend	STUDENT	Department of Physics,At/Po-	7325878794
9-9-2020 22:02:27	mediboinapreeti2001@gmail.com	Mediboina Preeti	Gunupur degree college, (	STUDENT	Bsc 2 nd year physics , roll no	8917631143
9-9-2020 22:31:52	stitirout@gmail.com	Stiti Rout	Aul degree college	STUDENT	+3 3rd yr Roll-005	9777219580
9-9-2020 23:07:04	ssmartsoumya143@gmail.com	SOUMYA RANJAN SAHO	Govt college Sundargarh	STUDENT	NA	9337234165
9-9-2020 23:15:47	sabyasachidash1999@gmail.com	SABYASACHI DASH	Pattamundai college, patta	STUDENT	+3 3rd year BS18-011	8763630790
9-10-2020 1:19:52	basuhm9@gmail.com	BASAVA	UNIVERSITY OF MYSOR	STUDENT	RESEARCH SCHOLAR	7204884910
9-10-2020 1:30:29	gajendrasoni2626@gmail.com	Gajendra Soni	Little Flower International	FACULTY	NA	09369086523
9-10-2020 2:01:28	rhiamarie.legarda@deped.gov.ph	RHIA MARIE LEGARDA L	AGKAWAYAN INTEGRAT	FACULTY	NA	09161246385
9-10-2020 2:22:58	merosayed300@gmail.com	Marwan Sayed Saad Moha	Ainshams university faculty	STUDENT	Student in biotechnology depa	+201102500516
9-10-2020 2:56:50	raypriyajit11@gmail.com	Priyajit Ray	University of Calcutta	STUDENT	Mphil	+918670353314
9-10-2020 3:58:39	soubir90@gmail.com	Soubir Das	Soubir Das	STUDENT	Research Scholar	+918918576412
9-10-2020 5:46:42	lakhwinderchatha790@gmail.com	Lakhwinder Singh	Dolphin PG college of Scie	STUDENT	M.Sc. Zoology, 03	7681971916
9-10-2020 6:04:12	haribandhu81@gmail.com	Haribandhu Bauri	Gunupur degree college, (	STUDENT	GN2019323	09078575943
9-10-2020 6:22:15	smitaprakash2018@gmail.com	Smita Praksah Biswal	Pattamundai Degree Colle	STUDENT	110	7008138081
9-10-2020 6:22:51	girlchilling@gmail.com	Sriram Barsharani	Gunpur Degree College, G	STUDENT	+3 second year, Bs-p-050	7854011799
9-10-2020 6:44:24	janmejaypradhan567@gmail.com	Janmejay Pradhan	Pattamundai degree colleg	STUDENT	+3 3rd year, BS17-146	8249435119
9-10-2020 6:49:31	adhikarirohit030@gmail.com	Rohit adhikari	Gunupur college, Gunupu	STUDENT	Class- +3 2nd year,science R	7989012588
9-10-2020 6:50:08	tridipdey96@gmail.com	Tridip Dey	Vidyasagar University	STUDENT	Bengali, M.A	9635630021

9-10-2020 7:09:41	chmkiran56hs@gmail.com	MARUTHI KIRAN CHALLA	ASHOKA INSTITUTE OF	FACULTY	NA	8121322517
9-10-2020 7:14:54	smrutiswasranjan@gmail.com	SUBRAT SMRUTI RANJAN	HINDOL COLLEGE KHAJ	FACULTY	NA	9776687420
9-10-2020 7:14:58	bijayamani1990@gmail.com	BIJAYA KUMAR PARIDA	DAYAVIHAR DEGREE CC	FACULTY	NA	7978782105
9-10-2020 7:23:37	mahaprasadswain95@gmail.com	Mahaprasad swain	Ssj.mahavidyalaya rajnaga	STUDENT	1802010740150067	9348749389
9-10-2020 7:28:34	pradyumna.bir@gmail.com	Mr PRADYUMNA PRADHA	Pattamundai College	FACULTY	NA	9776010619
9-10-2020 7:36:04	rcgsumerpur@gmail.com	RAMESH CHANDRA GUPT	Late SLS PG College Mak	FACULTY	NA	7905704569
9-10-2020 7:42:15	19201020@ksrm.ac.in	Manoj Madkami	Kiit School of Rural Manag	STUDENT	NA	7077864006
9-10-2020 7:45:39	toshashu920@gmail.com	ASHUTOSH BEHERA	SALIPUR AUTONOMOUS	STUDENT	B. SC, ROLL NO. :BS(P)19-20	7684979106
9-10-2020 7:57:30	devidgautan59@gmail.com	Danij Gautam	Dr. Rajendra Prasad Degr	STUDENT	B Ed of Student Teacher	9520763263
9-10-2020 7:59:22	rathorejaiendra@gmail.com	JAIENDRA SINGH RATHO	DELHI PUBLIC SCHOOL .	FACULTY	NA	9300098517
9-10-2020 8:06:18	kanchansharmargp02@gmail.com	Nupur Kumari	S.A.I.E.R.C	STUDENT	Class 9 ; Roll-no 18	9337298009
9-10-2020 8:11:56	yoganarasimhatk@gmail.com	T K Yoganarasimha	Siddaganga Institute of Te	STUDENT	III Year, B.E , Mechanical	9844426236
9-10-2020 8:16:05	silensutar@gmail.com	SILEN SUTAR	Sanskar Academy,Dhenka	FACULTY	NA	7205730850
9-10-2020 8:17:15	tapaswininayak746@gmail.com	Tapaswini Nayak	Shishu Ananta Mahavidyal	STUDENT	+3 3rd yr. Sci.(Phy. Hons.)Ro	6371837676
9-10-2020 8:22:45	dr.spdewangan@gmail.com	Dr. Sharad Kumar Dewang	Dr B.S.P. Govt. College, P	FACULTY	No	9770175133
9-10-2020 8:27:01	milensutar@gmail.com	Milen sutar	A.S college tirtol	STUDENT	Bsc 2nd yr, roll no.09	8917419498
9-10-2020 8:33:38	skp10877@gmail.com	SANDIP KUMAR PRADHA	Ravenshaw University	STUDENT	45	7008450621
9-10-2020 8:34:42	ranjitmohanty11544@gmail.com	RANJIT MOHANTY	RANJIT MOHANTY	STUDENT	50	6372923169
9-10-2020 8:41:28	malikdipti37@gmail.com	Deeparani malik	Autonomous college, kend	STUDENT	Bsc,3rd yr (physical science),F	9668511375
9-10-2020 8:44:42	subhasreepanigrahignpr01@gmail.com	Subhasree panigrahi	Gunupur degree college	STUDENT	Bsc & BS18-023	8018177792
9-10-2020 8:44:48	mk971594@gmail.com	B. Manish Kumar	Gunupur college, gunupur	STUDENT	BSE physics honours, Clz roll	9861351935
9-10-2020 8:45:25	kumarpradipt@gmail.com	DR. PRADIPTA KUMAR	CHARAMPA DEGREE CC	FACULTY	NA	7873977166
9-10-2020 8:50:33	subhasreepadhi468@gmail.com	Subhasree Padhi	Gunupur college, Gunupur	STUDENT	Bsc Final year, BS-18-058	6371832373
9-10-2020 8:50:48	Biswaprakashmohapatra2017@gmail.c	Biswaprakash mohapatra	Govindpur degree college	STUDENT	+3 final year, Roll no:-347	7609908202
9-10-2020 8:52:00	ganeswarmallik84@gmail.com	Ganeswar mallik	Pattamundai degree colleg	STUDENT	76	8917577734
9-10-2020 8:57:04	salinapatita2001@gmail.com	Salina Patita	Gunupur Degree College,	STUDENT	+3 3rd yr, physics hons.,roll no	6371752940
9-10-2020 8:58:54	baishakhigayan@gmail.com	Baishakhi Gayan	ASD , Tirtol	STUDENT	Class :-+3 2nd year,roll no.32	7750803848
9-10-2020 8:59:12	ankitasahoo37153@gmail.com	ANKITA SAHOO	Pattamundai college, patta	STUDENT	3rd year,roll no.-099	9861599073
9-10-2020 8:59:37	satyabratasahoo010@gmail.com	Satyabrata sahoo	sambalpur university	STUDENT	B.sc 3rd year, BS-18 006	9348666281
9-10-2020 9:00:31	pssahoo01@gmail.com	Subhasharee Priyadarshini	Sishu Ananta Mahavidyala	STUDENT	BS-18-118 & +3 3rd yr sc	8144039503
9-10-2020 9:01:36	sactomar@gmail.com	Sachin Tomar	Govt Boys Senior Seconda	FACULTY	NA	9971860770
9-10-2020 9:01:41	shewliroy241279@gmail.com	Mrs SHEWLI ROY	DARGAKUNA BAGAN LP	FACULTY	NA	9854761237
9-10-2020 9:03:47	alokmallik55473@gmail.com	Alok Mallik	Pattamundai Degree Colle	STUDENT	75	8328801875
9-10-2020 9:03:49	viratiansweta@gmail.com	Jayaspeta Bardhan	Gunupur degree college, g	STUDENT	Bs-18-010	6371010335
9-10-2020 9:05:53	architapandalinu123@gmail.com	Archita panda	Pattamundai degree colleg	STUDENT	+3 2nd yr and BS(B)19-021	7853842716

9-10-2020 9:08:17	09kiratkuar1@gmail.com	Gurpreet Kaur	Jagat Sewak Khalsa Sen.	FACULTY	NA	579096560
9-10-2020 9:13:51	archanamallick54@gmail.com	Archana Mallick	Pattamundai degree colleg	STUDENT	Bs17114	9439940882
9-10-2020 9:14:04	shahrashil1112@gmail.com	SHAH RASHIL HIREN	GEC PATAN	STUDENT	1.9022E+11	9316768140
9-10-2020 9:15:36	nikhilrajranguli3@gmail.com	Nikhil Raj Ranguli	Gunupur college , Gunupu	STUDENT	+3 2nd year Bsc Physics , B	9348020827
9-10-2020 9:20:02	laxmipriya8908@gmail.com	Laxmipriya patra	Pattamundai college	FACULTY	NA	9437550615
9-10-2020 9:20:54	nibedita006@gmail.com	NIBEDITA PRADHAN	Pattamundai COllege	FACULTY	NA	8260531432
9-10-2020 9:20:59	hkmphysics11@gmail.com	Dr Hemanta Kumar Mishra	Shishu Ananta Mahavidyal	FACULTY	NA	9437168168
9-10-2020 9:23:16	muthurathi2001@gmail.com	Ms.N.MUTHURATHI	Pallavan pharmacy college	STUDENT	B pharm	9962134319
9-10-2020 9:27:49	bindunalla123@gmail.com	Bindu kumari nalla	Gunupur degree college	STUDENT	Bsc 2nd year (phy)& roll no:B	9348573073
9-10-2020 9:29:04	abinanthan.me18@bitsathy.ac.in	ABINANTHAN M K	BANNARI AMMAN INSTIT	STUDENT	III YEAR&181ME104	9976384052
9-10-2020 9:34:01	siddheswaripandit@gmail.com	Siddheswari pandit	Gunupur degree college	STUDENT	Bs18074	9348571681
9-10-2020 9:34:25	miniswaribhuyan@gmail.com	Miniswari Bhuyan	Gunupur (degree)collage	STUDENT	Roll no Bs-18-121	8895537194
9-10-2020 9:34:29	tejaswinipedenti449@gmail.com	Tejaswini Pedenti	Gunupur Degree college ,	STUDENT	+3 final year, BS18021	8144297449
9-10-2020 9:39:22	kumarprateek1818@gmail.com	Prateek Kumar Nayak	Aul Degree College,Aul	STUDENT	+3 3rd year (physics),BS18-02	7381736928
9-10-2020 9:40:46	bhabanidassankar@gmail.com	Bhabani Sankar Das	Gandhi institute of technol	STUDENT	2nd Year & 182032	9668208709
9-10-2020 9:54:32	rajeshkumarroul3@gmail.com	Rajesh Kumar Roul	Pattamundai College, Patt	STUDENT	BS(P)19-002	7735916403
9-10-2020 9:55:00	satyajitmohanty135@gmail.com	Satyajit Mohanty	Pattamundai college	STUDENT	+3 3rd year ,083	9861920069
9-10-2020 9:55:14	nalu60.60@gmail.com	Satya Prakash Nayak	Bhadrak Autonomous Coll	STUDENT	Bsc 3rd yr, BS18-120	8112071855
9-10-2020 9:57:34	lakkilash1987@gmail.com	LAKSHMI S	LAKSHMI S	FACULTY	NA	8951521842
9-10-2020 10:29:15	rajarshimondal.2002@gmail.com	Rajarshi Mondal	Indian Association for the	STUDENT	Second year(Academic year)	9674698069
9-10-2020 10:39:37	sd4.subratdas@gmail.com	Subrat Das	Pattamundai College	STUDENT	B.Sc 3rd year, BS18-002	9348400572
9-10-2020 10:44:05	subhramjit46@gmail.com	Subhasmita nayak	Gyana vikash junior colleg	FACULTY	Department of zoology	9937056368
9-10-2020 10:57:17	bsvas26@gmail.com	BANOTHU SREENU	Mother Theresa College of	FACULTY	NA	9676222163



Pattamundai College, Pattamundai

CERTIFICATE OF PARTICIPATION

This is to certify that

Dr. Ramesh Kumar Sahoo

From

Pattamundai College

has participated a webinar on "PHYSICS OF STARS" organized by Department of Physics on 10Th September 2020.

Convener **Resource Person** **Principal**

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜରେ ୱେବିନାର

THE PRAGATIBADI on 29.09.20

ପଞ୍ଚାମୁଣ୍ଡାଇ,ପି.ଏନ୍.ଏସ:ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଫିଜିକ୍ସ ଅଫ ଷ୍ଟାରସ ଶୀର୍ଷକ ୱେବିନାର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରହିତ୍ୟରେ ଗତ ୨୮/୦୯/୨୦୨୦ରିଖରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ଏଥିରେ ତିରୁପତି ଆଇଆଇଟିର ପୋଷ୍ଟ ଡକ୍ଟରାଲ ଫେଲୋ ଡ. ସ୍ୱାଗତ ଦାଶ ଯୋଗ ଦେଇ ମହାକାଶରେ ତାରାମାନଙ୍କ ସୃଷ୍ଟି, ଶକ୍ତି, ପ୍ରବାହ ଓ ବିଲୟ ସଂପର୍କରେ ବିଶଦ ଆଲୋଚନା କରିଥିଲେ । ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସଂପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଭାରତ ଅତିଥିପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ । ସେହିପରି କଲେଜ ଉଦ୍ଭିଦ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଜଳବାୟୁ ପରିବର୍ତ୍ତନ ଓ କୃଷି ଶୀର୍ଷକ ୱେବିନାର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ଏଥିରେ ସେଣ୍ଟ୍ରାଲ କେରଳ ବିଶ୍ୱବିଦ୍ୟାଳୟର ସହକାରୀ ପ୍ରଫେସର ଡ [illegible] ପଣ୍ଡା ଯୋଗ ଦେଇ କୃଷି ଉପରେ ଜଳବାୟୁ ପରିବର୍ତ୍ତନର ପ୍ରଭାବ ସଂପର୍କରେ ବିଶେଷ ଆଲୋଚନା କରିଥିଲେ । କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶ ସ୍ୱାଗତଭାଷଣ ଦେଇଥିଲେ । ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ଉଦ୍ଭିଦ ବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ. ଅଞ୍ଜଳି ଦାଶ ଅତିଥିପରିଚୟ ପ୍ରଦାନ କରି କାର୍ଯ୍ୟକ୍ରମ ସଂପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । ଶିକ୍ଷା ଅଧ୍ୟାପିକା ନିରୁପମା ସ୍ୱାଇଁ କାର୍ଯ୍ୟକ୍ରମ ପରିଚାଳନା କରିଥିବାବେଳେ ଉଦ୍ଭିଦ ବିଜ୍ଞାନ ବିଭାଗ ଅଧ୍ୟାପିକା ଶ୍ରୀସ୍ମିତା ବିଶ୍ୱାଳ ଧନ୍ୟବାଦ ଦେଇଥିଲେ । ଏଥିରେ ବହୁ ଅଧ୍ୟାପକ/ଅଧ୍ୟାପିକା ଓ ଛାତ୍ରଛାତ୍ରୀ ଯୋଗ ଦେଇଥିଲେ ।

Date- 29.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ବିଭାଗ ୱେବିନାର

ପଞ୍ଚାମୁଣ୍ଡାଇ, ୨୮।୯ (ନି.ପ୍ର): ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଫିଜିକ୍ସ ଅଫ ଷ୍ଟାରସ୍ ଶୀର୍ଷକ ୱେବିନାର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରୋହିତ୍ୟରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ଏଥିରେ ତିରୁପତି ଆଇଆଇଟିର ପୋଷ୍ଟ ଡକ୍ଟରାଲ ଫେଲୋ ଡ. ସ୍ୱାଗତ ଦାଶ ମହାକାଶରେ ତାରାଙ୍କ ସୃଷ୍ଟି, ଶକ୍ତି, ପ୍ରବାହ ଓ ବିଲୟ ସଂପର୍କରେ ଆଲୋଚନା କରିଥିଲେ । ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ. ରମେଶକୁମାର ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସଂପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଭାରତ ଅତିଥିପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ । ଶେଷରେ ଛାତ୍ରୀ ଦୀପିକା ଦାସ ଧନ୍ୟବାଦ ଦେଇଥିଲେ ।

THE SAMAJA on 29.09.2020

Date – 29.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ଓ ରସାୟନ ବିଜ୍ଞାନ ବିଭାଗ ୱେବିନାର

ODISHA EXPRESS

29.09.2020

ପଞ୍ଚାମୁଣ୍ଡାଇ, ୨୮।୯ : ଏକ୍ସପ୍ରେସ ନ୍ୟୁଜ୍

ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଫିଜିକ୍ସ ଅଫ ଷ୍ଟାରସ ଶୀର୍ଷକ ୱେବିନାର କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶଙ୍କ ପୌରହିତ୍ୟରେ ଗତ ୧୦ତାରିଖରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ଏଥିରେ ତିରୁପତି ଆଇଆଇଟିର ପୋଷ୍ଟ ଡକ୍ଟରାଲ ଫେଲୋ ଡ. ସ୍ୱାଗତ ଦାଶ ଯୋଗଦେଇ ମହାକାଶରେ ତାରାମାନଙ୍କ ସୃଷ୍ଟି, ଶକ୍ତି, ପ୍ରବାହ ଓ ବିଲୟ ସଂପର୍କରେ ବିଶଦ ଆଲୋଚନା କରିଥିଲେ । ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ.ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସଂପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠ ଭାରତ ଅତିଥି ପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ । ଶେଷରେ ଛାତ୍ରୀ ଦୀପିକା ଦାସ ଧନ୍ୟବାଦ ଦେଇଥିଲେ । ଏହି ଆଲୋଚନାଚକ୍ରରେ ବହୁ ଅଧ୍ୟାପକ, ଅଧ୍ୟାପିକା ଓ ଛାତ୍ରଛାତ୍ରୀ ଯୋଗ ଦେଇଥିଲେ ।

ସେହିପରି ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ରସାୟନ ବିଜ୍ଞାନ ଦି ରୋଲ ଅଫ କେମିଷ୍ଟ୍ରି ଇନ ଦ ସଷ୍ଟେନେବୁଲ ଡେଭେଲପମେଣ୍ଟ ଅଫ ସୋସାଇଟି ଶୀର୍ଷକ ୱେବିନାର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ଏଥିରେ ଉତ୍ତର ଓଡ଼ିଶା ବିଶ୍ୱବିଦ୍ୟାଳୟର ରସାୟନ ବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ପ୍ରଫେସର ଡ. ପ୍ରମୋଦ କୁମାର ଶତପଥୀ ଯୋଗଦେଇ ଆଜିର ସମାଜରେ ରସାୟନ ବିଜ୍ଞାନର ଉପଯୋଗିତା ଓ ଉପାଦେୟତା ସଂପର୍କରେ ବିଶଦ ଆଲୋଚନା କରିଥିଲେ । ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ଅଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଧିକାରୀ ଲକ୍ଷ୍ମୀନାରାୟଣ ଦାଶ ସ୍ୱାଗତ ଭାଷଣ ଦେଇ ଅତିଥି ଓ ଅଂଶଗ୍ରହଣକାରୀଙ୍କୁ ସ୍ୱାଗତ କରିଥିଲେ । ପଞ୍ଚାମୁଣ୍ଡାଇ କଲେଜ ରସାୟନବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ.ଦୁଃଶାସନ ପଣ୍ଡିତ ଅତିଥିପରିଚୟ ପ୍ରଦାନ କରିଥିଲେ । ଅଧ୍ୟାପକ ରଞ୍ଜନ କୁମାର ସାହାଣୀ ପ୍ରଶ୍ନୋତ୍ତର କାର୍ଯ୍ୟକ୍ରମ ସଂଯୋଜନା କରିଥିଲେ । ଶେଷରେ ପ୍ରାଧ୍ୟାପକ ଡ. ସୁଶୀଲ ପ୍ରଧାନ ଧନ୍ୟବାଦ ଦେଇଥିଲେ । ଏହି କାର୍ଯ୍ୟକ୍ରମକୁ ଶୁଭାଶୀଷ ମିଶ୍ର, ପ୍ରାଧ୍ୟାପକ ଡ. ନୀଳମଣି ସେଠୀ, ଡ. ପ୍ରମୋଦ ନାୟକ, ମନୋଜ ଦ୍ୱିବେଦୀ, ଦିଲ୍ଲୀପ କୁମାର, ଅର୍ଚ୍ଚନା ଦାଶ, ଅଧ୍ୟାପିକା ପ୍ରଜ୍ଞାପ୍ରଭା ସ୍ୱାଇଁ, ବିବେକ ରଞ୍ଜନ ପ୍ରମୁଖ ପରିଚାଳନା କରିଥିଲେ ।

Date - 29.09.2020

A SEMINAR

ON

“SPACE QUANTIZATION VECTOR MODEL”

Presented by:

Mr.Rama Chandra Patra

Reader in Physics Kendrapara
Autonomous College, Kendrapara.

On

21th Nov 2019

DEPARTMENT OF PHYSICS

PATTAMUDAI COLLEGE,

PATTAMUNDAI.

REPORT

A seminar was organised by Department of Physics, Pattamundai College, pattamundai on 21.11.2019 on the topic “SPACE QUANTIZATION VECTOR MODEL”. Mr. Rama Chandra Patra, Reader in Physics Kendrapara Autonomous College, Kendrapara, was the resource person for the seminar. In this seminar, Dr Ramesh Kumar Sahoo, Head of the Department chaired the meeting and welcomed the guests on the dais as well as participants .Mr. Baikunth Charan Roul gave a key note of the topic. The meeting was ended with vote of thanks by Mr. Tarakanta Maharana, another faculty member.

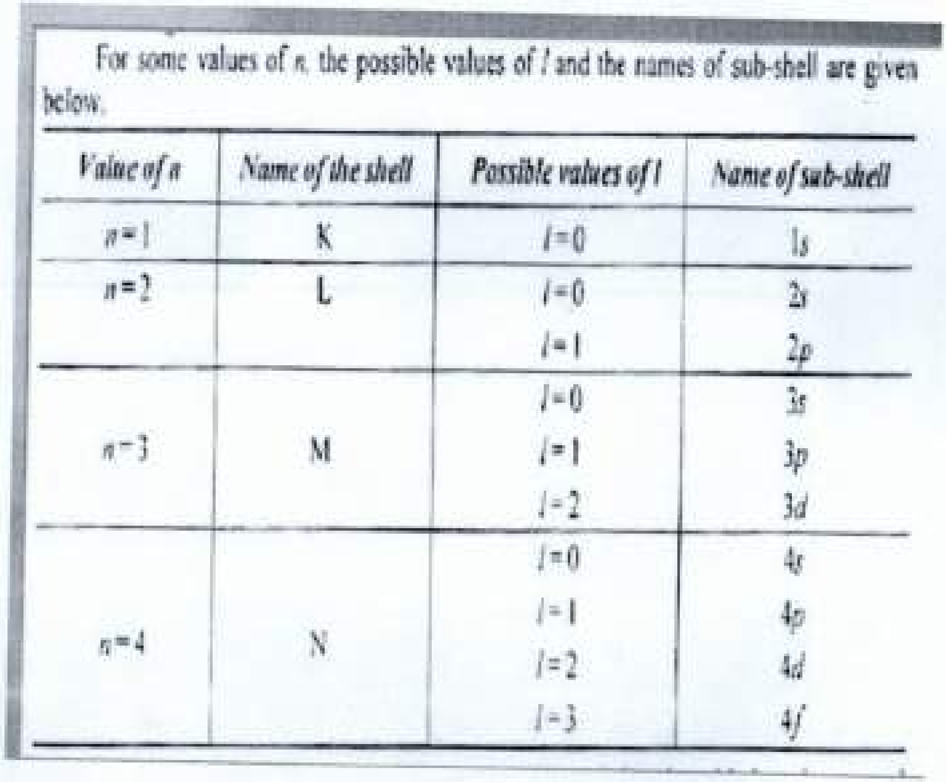
Space quantization vector model

BY

RAMA CHANDRA PATRA

Reader in Physics

Kendrapara Autonomous College , Kendrapara



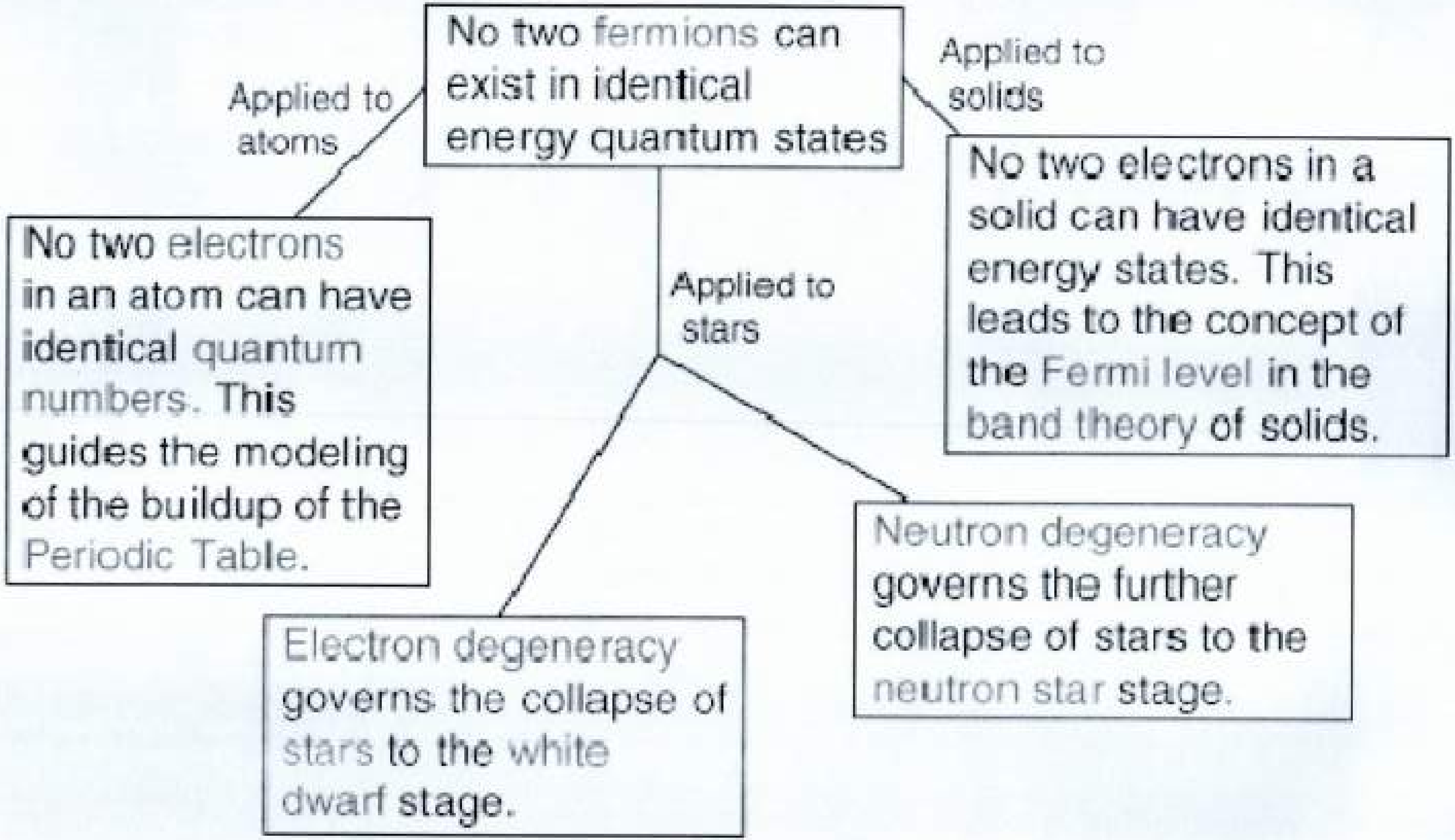
For some values of n, the possible values of l and the names of sub-shell are given below.

Value of n	*Name of the shell*	*Possible values of l*	*Name of sub-shell*
$n=1$	K	$l=0$	1*s*
$n=2$	L	$l=0$	2*s*
		$l=1$	2*p*
$n=3$	M	$l=0$	3*s*
		$l=1$	3*p*
		$l=2$	3*d*
$n=4$	N	$l=0$	4*s*
		$l=1$	4*p*
		$l=2$	4*d*
		$l=3$	4*f*

Atomic Physics: Vector Atom model

- Space quantization
- Electron spin
- Quantum numbers
- Pauli`s Exclusion principle
- Stern Gerlach Experiment
- LS and JJ coupling schemes for two electrons
- Zeeman effect- Normal, anomalous
- Stark effect

Pauli Exclusion Principle



No two fermions can exist in identical energy quantum states

Applied to atoms

No two electrons in an atom can have identical quantum numbers. This guides the modeling of the buildup of the Periodic Table.

Applied to solids

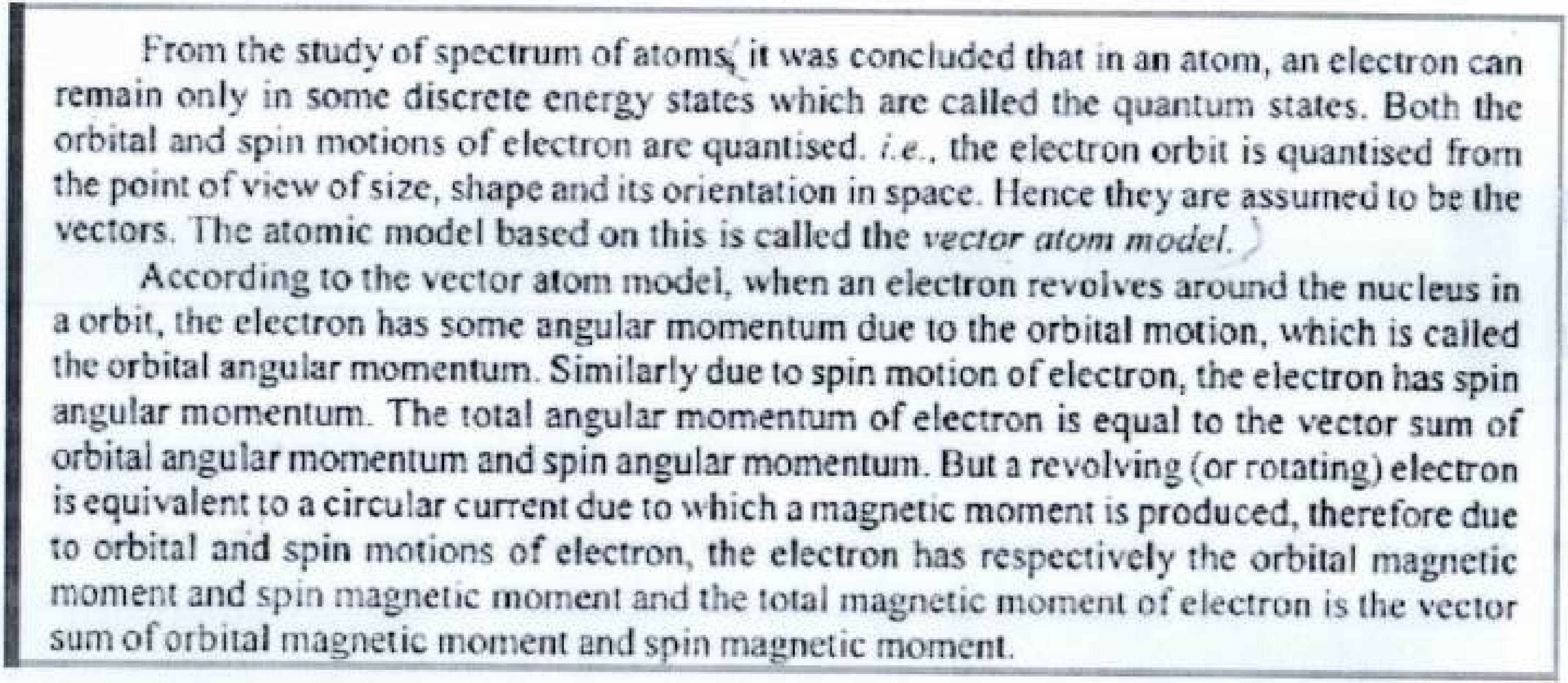
No two electrons in a solid can have identical energy states. This leads to the concept of the Fermi level in the band theory of solids.

Applied to stars

Electron degeneracy governs the collapse of stars to the white dwarf stage.

Neutron degeneracy governs the further collapse of stars to the neutron star stage.

Vector model and quantum numbers associated with an electron



From the study of spectrum of atoms, it was concluded that in an atom, an electron can remain only in some discrete energy states which are called the quantum states. Both the orbital and spin motions of electron are quantised. *i.e.*, the electron orbit is quantised from the point of view of size, shape and its orientation in space. Hence they are assumed to be the vectors. The atomic model based on this is called the *vector atom model.*

According to the vector atom model, when an electron revolves around the nucleus in a orbit, the electron has some angular momentum due to the orbital motion, which is called the orbital angular momentum. Similarly due to spin motion of electron, the electron has spin angular momentum. The total angular momentum of electron is equal to the vector sum of orbital angular momentum and spin angular momentum. But a revolving (or rotating) electron is equivalent to a circular current due to which a magnetic moment is produced, therefore due to orbital and spin motions of electron, the electron has respectively the orbital magnetic moment and spin magnetic moment and the total magnetic moment of electron is the vector sum of orbital magnetic moment and spin magnetic moment.

For some values of n, the possible values of l and the names of sub-shell are given below.

Value of n	*Name of the shell*	*Possible values of l*	*Name of sub-shell*
$n = 1$	K	$l = 0$	$1s$
$n = 2$	L	$l = 0$	$2s$
		$l = 1$	$2p$
$n = 3$	M	$l = 0$	$3s$
		$l = 1$	$3p$
		$l = 2$	$3d$
$n = 4$	N	$l = 0$	$4s$
		$l = 1$	$4p$
		$l = 2$	$4d$
		$l = 3$	$4f$

Stern-Gerlach experiment

- This experiment confirmed the quantisation of electron spin into two orientations.

$$\Delta E = -\hat{\mu}_s \cdot \hat{B} = -\mu_{s_z} B$$
$$= g_s \mu_B m_s B$$

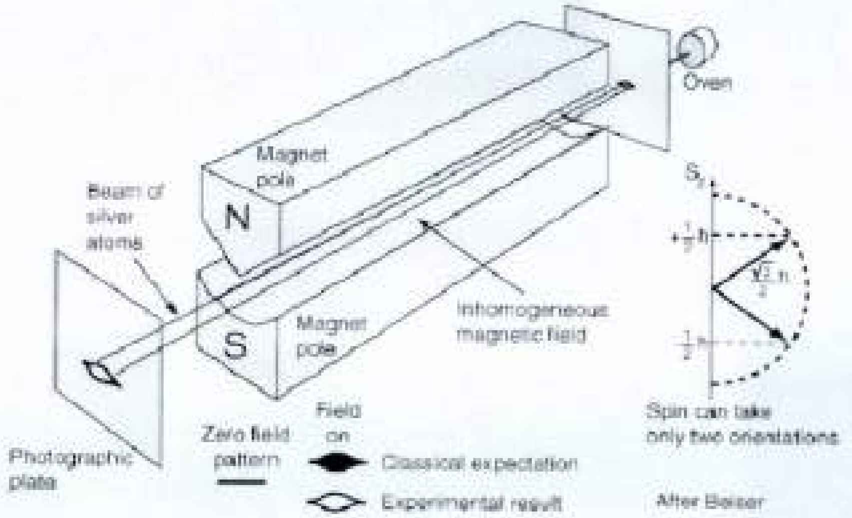
- Potential energy of electron spin magnetic moment in magnetic field in z-direction is

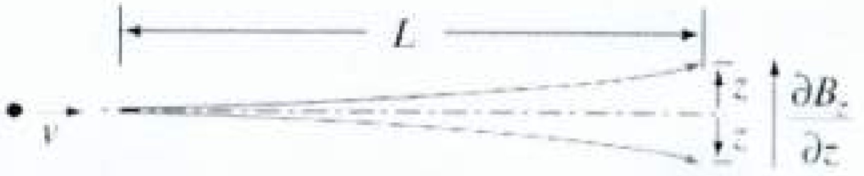
$$F_z = -\frac{d(\Delta E)}{dz} = -\mu_B g_s m_s \frac{dB_z}{dz}$$

- The resultant force is
- As $g_s m_s = \pm 1$,
- The deflection distance is then,

$$F_z = \pm \mu_B \frac{dB_z}{dz}$$

$$z = 1/2at^2 = 1/2\frac{F}{m}\left[\frac{L}{v}\right]^2 = \pm\frac{\mu_B L^2}{4KE}\frac{dB_z}{dz}$$





Pauli Exclusion Principle

- To understand atomic spectroscopic data, Pauli proposed his exclusion principle:

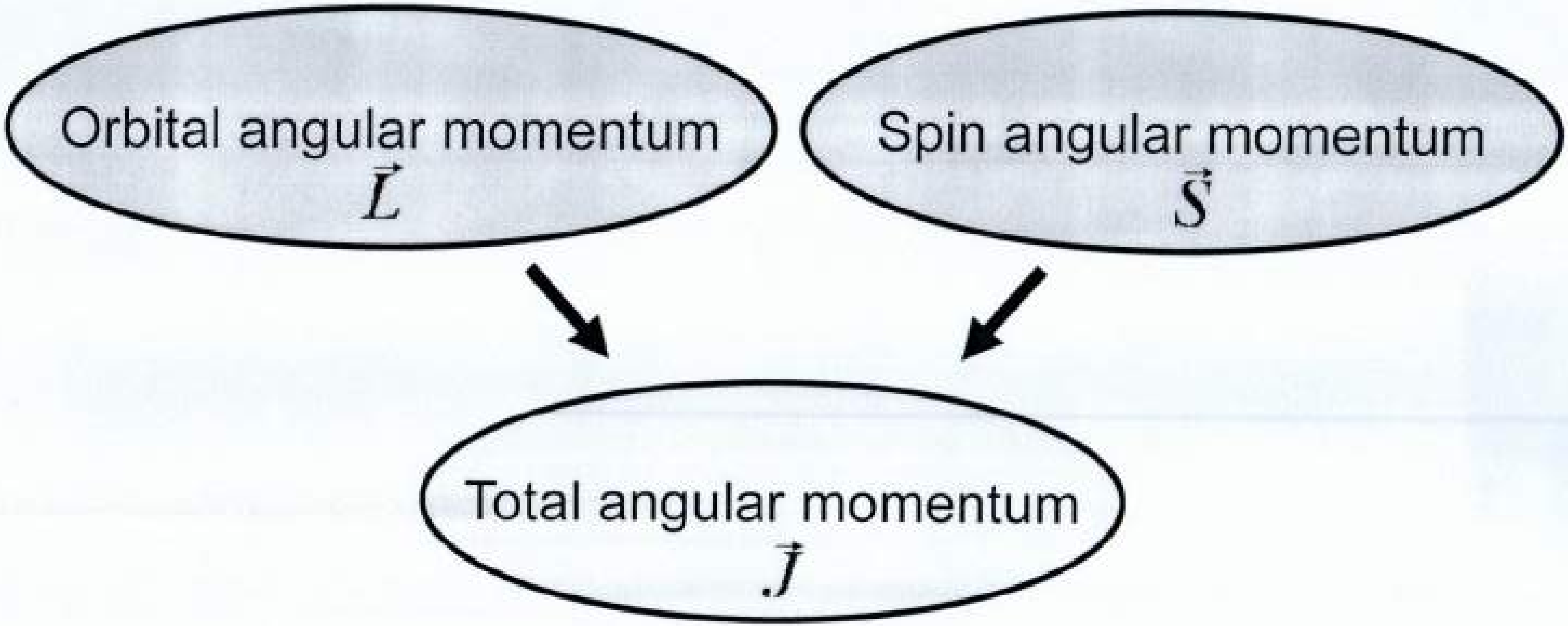
- **No two electrons in an atom may have the same set of quantum numbers (n, ℓ, m_ℓ, m_s).**

- It applies to all particles of half-integer spin, which are called *fermions*, and particles in the nucleus are also fermions.

- The periodic table can be understood by two rules:

- The electrons in an atom tend to occupy the lowest energy levels available to them.
- The Pauli exclusion principle.

Total Angular Momentum



Orbital angular momentum
$\vec{L}$

Spin angular momentum
$\vec{S}$

Total angular momentum
$\vec{J}$

$$\boxed{\vec{J} = \vec{L} + \vec{S}}$$

- L, L_z, S, S_z, J, and J_z are quantized.

Total Angular Momentum

- If *j* and m_j are quantum numbers for the single-electron hydrogen atom:

$$\boxed{\begin{aligned} J &= \sqrt{j(j+1)}\hbar \\ J_z &= m_j\hbar \end{aligned}}$$

- Quantization of the magnitudes:

$$\boxed{\begin{aligned} L &= \sqrt{\ell(\ell+1)}\hbar \\ S &= \sqrt{s(s+1)}\hbar \\ J &= \sqrt{j(j+1)}\hbar \end{aligned}}$$

- The total angular momentum quantum number for the single electron can only have the v

$$\boxed{j = \ell \pm s}$$

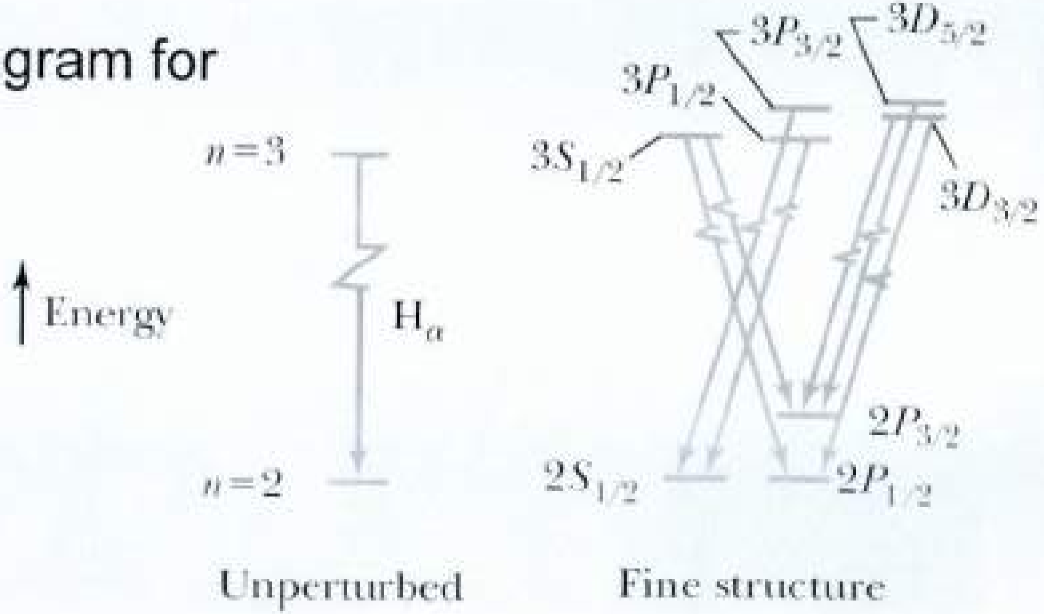
Total Angular Momentum

- Now the selection rules for a single-electron atom become

$-\Delta n$ = anything $\Delta \ell = \pm 1$

$-\Delta m_j = 0, \pm 1$ $\Delta j = 0, \pm 1$

- Hydrogen energy-level diagram for $n = 2$ and $n = 3$ with spin-orbit splitting.



Many-Electron Atoms

- **Hund's rules**:

- The total spin angular momentum *S* should be maximized to the extent possible without violating the Pauli exclusion principle.
- Insofar as rule 1 is not violated, *L* should also be maximized.
- For atoms having subshells less than half full, *J* should be minimized.

- For a two-electron atom

- There are ***LS* coupling** and ***jj* coupling** to combine four angular momenta *J*.

$$\boxed{\vec{J} = \vec{L}_1 + \vec{L}_2 + \vec{S}_1 + \vec{S}_2}$$

Zeeman Effect

- First reported by Zeeman in 1896. Interpreted by Lorentz.

- Interaction between atoms and field can be classified into two regimes:
  - Weak fields: *Zeeman effect*, either *normal* or *anomalous*.
  - Strong fields: *Paschen-Back effect*.

- Normal Zeeman effect agrees with the classical theory of Lorentz. Anomalous effect depends on electron spin, and is purely quantum mechanical.

$B = 0$

$B > 0$

Norman Zeeman effect

- Observed in atoms with no spin.
- Total spin of an *N*-electron atom is $\hat{S} = \sum_{i=1}^{N} \hat{s}_i$
- Filled shells have no net spin, so only consider valence electrons. Since electrons have spin 1/2, not possible to obtain $S = 0$ from atoms with odd number of valence electrons.
- Even number of electrons can produce $S = 0$ state (e.g., for two valence electrons, $S = 0$ or 1).
- All ground states of Group II (divalent atoms) have ns^2 configurations => always have $S = 0$ as two electrons align with their spins antiparallel.

$$\hat{\mu} = -\frac{\mu_B}{\hbar}\hat{L}$$

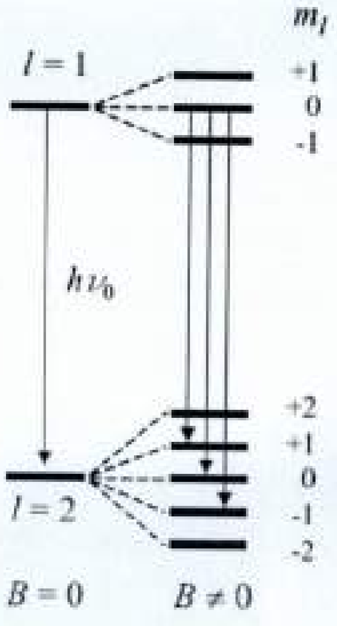
- Magnetic moment of an atom with *no spin* will be due entirely to *orbital* motion:

Norman Zeeman effect transitions

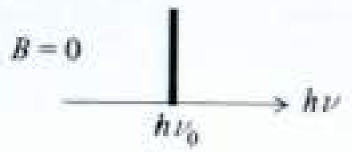
- But what transitions occur? Must consider selections rules for m_l: $\Delta m_l = 0, \pm 1$.

- Consider transitions between two Zeeman-split atomic levels. Allowed transition frequencies are therefore,

$$\begin{aligned} h\nu &= h\nu_0 + \mu_B B_z & \Delta m_l &= -1 \\ h\nu &= h\nu_0 & \Delta m_l &= 0 \\ h\nu &= h\nu_0 - \mu_B B_z & \Delta m_l &= +1 \end{aligned}$$



- Emitted photons also have a polarization, depending on which transition they result from.

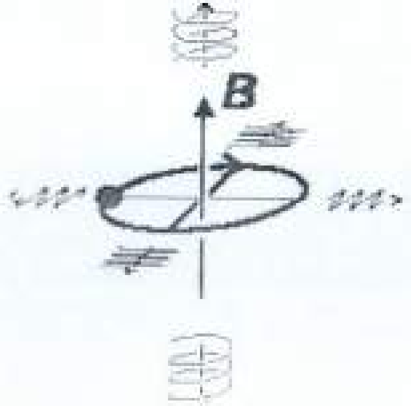


Norman Zeeman effect transitions

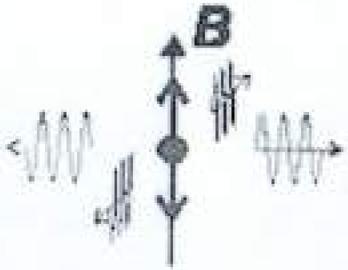
- Last two columns of table below refer to the polarizations observed in the longitudinal and transverse directions.
- The direction of circular polarization in the longitudinal observations is defined relative to *B*.
- Interpretation proposed by Lorentz (1896)

Δm_l	Energy	Polarization Longitudinal observation	 Transverse observation
+1	$h\nu_0 - \mu_B B$	σ^+	$\mathcal{E} \perp B$
0	$h\nu_0$	not observed	$\mathcal{E} \parallel B$
-1	$h\nu_0 + \mu_B B$	σ^-	$\mathcal{E} \perp B$

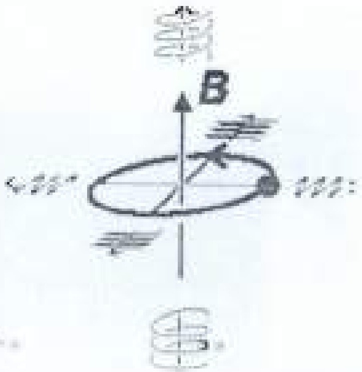
σ^-
$(\Delta m_l=-1)$



π
$(\Delta m_l=0)$



σ^+
$(\Delta m_l=+1)$



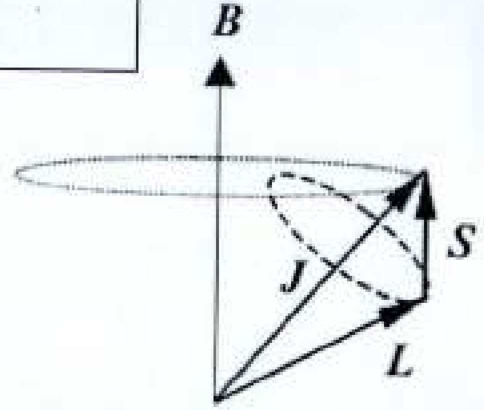
Anomalous Zeeman effect

- Discovered by Thomas Preston in Dublin in 1897.
- Occurs in atoms with non-zero spin => atoms with odd number of electrons.
- In LS-coupling, the spin-orbit interaction couples the spin and orbital angular momenta to give a total angular momentum according to

$$J = L + S$$

- In an applied B-field, J precesses about B at the Larmor frequency.
- L and S precess more rapidly about
- J to due to spin-orbit interaction.

Spin-orbit effect therefore stronger.



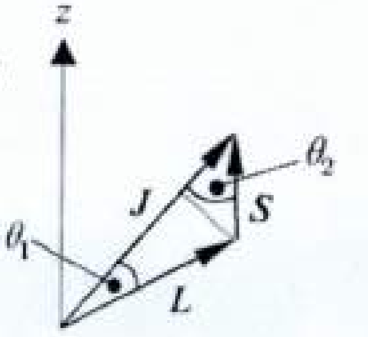
Anomalous Zeeman effect

- Interaction energy of atom is $E = \mu_z$ equal to sum of interactions of spin and orbital magnetic moments with *B*-field: $-(\mu_z^{orbital} + \mu_z^{spin})B_z$

$$= \left\langle \hat{L}_z + g_s \hat{S}_z \right\rangle \frac{\mu_B}{\hbar} B_z$$

$$\hat{S}_z = 0 \qquad \hat{L}_z = m_l \hbar.$$

where $g_s = 2$, and the < … > is the expectation value. The normal Zeeman effect is obtained by setting and $J_z = m_j \hbar$



- In the case of precessing atomic magnetic in figure on la: nor L_z are constant. Only is well defined.

$$\hat{\mu} = -\left\langle |\hat{L}| \cos\theta_1 \frac{\hat{J}}{|\hat{J}|} + 2|\hat{S}| \cos\theta_2 \frac{\hat{J}}{|\hat{J}|} \right\rangle \frac{\mu_B}{\hbar}$$

- Must therefore project *L* and *S* onto *J* and project onto z-axis =>

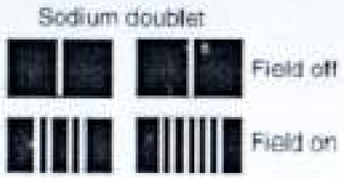
"Normal" Zeeman effect

This type of splitting is observed with hydrogen and the zinc singlet.

This type of splitting is observed for spin 0 states since the spin does not contribute to the angular momentum.

"Anomalous" Zeeman effect

When electron spin is included, there is a greater variety of splitting patterns.



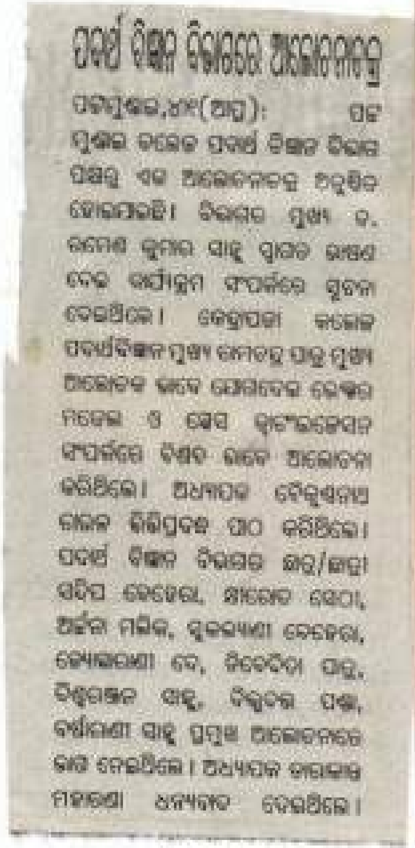
21/11/19

ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ଆଲୋଚନାଚକ୍ର

ପଟ୍ଟାମୁଣ୍ଡାଇ, ୪ା୧ : ଏକ୍ସପ୍ରେସ୍ ନ୍ୟୁଜ୍

ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସମ୍ପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । କେନ୍ଦ୍ରାପଡ଼ା କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ମୁଖ୍ୟ ଭାନଚନ୍ଦ୍ର ପାତ୍ର ମୁଖ୍ୟଆଲୋଚକ ଭାବେ ଯୋଗଦେଇ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ସମ୍ପର୍କରେ ବିଶଦ ଭାବେ ଆଲୋଚନା କରିଥିଲେ । ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠନାଥ ଭାଉଳ ଲିଖିତପ୍ରବନ୍ଧ ପାଠ କରିଥିଲେ । ପଦାର୍ଥବିଜ୍ଞାନ ବିଭାଗର ଛାତ୍ରଛାତ୍ରୀ ସନ୍ଦୀପ ବେହେରା, କ୍ଷୀରୋଦ ସେଠୀ, ଅର୍ଚ୍ଚନା ମଲ୍ଲିକ, ସୁକଲ୍ୟାଣୀ ବେହେରା, ଜ୍ୟୋତ୍ସ୍ନାରାଣୀ ଦେ, ନିବେଦିତା ପାତ୍ର, ବିଶ୍ୱରଞ୍ଜନ ସାହୁ, ବିଜୁଦତ୍ତ ପଣ୍ଡା, ବର୍ଷାରାଣୀ ସାହୁ ପ୍ରମୁଖ ଆଲୋଚନାରେ ଭାଗ ନେଇଥିଲେ । ଶେଷରେ ଅଧ୍ୟାପକ ତାରାକାନ୍ତ ମହାରଣା ଧନ୍ୟବାଦ ଦେଇଥିଲେ ।

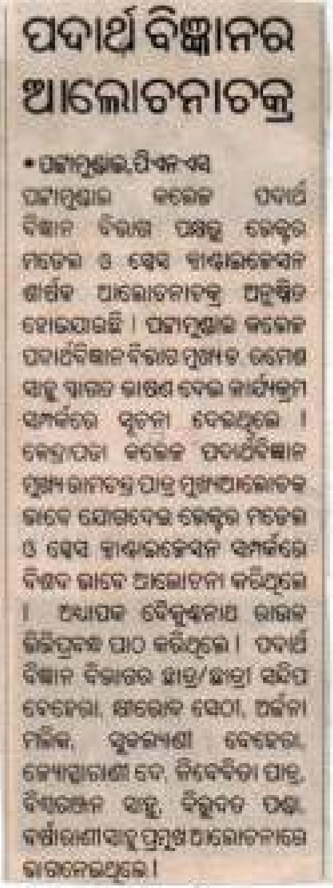
Odisha Express



ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗରେ ଆଲୋଚନାଚକ୍ର

ପଟ୍ଟାମୁଣ୍ଡାଇ,୪ା୧(ଅପ୍ର): ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଏକ ଆଲୋଚନାଚକ୍ର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ବିଭାଗର ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସଂପର୍କରେ ସୂଚନା ଦେଇଥିଲେ। କେନ୍ଦ୍ରାପଡ଼ା କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ମୁଖ୍ୟ ଭାନଚନ୍ଦ୍ର ପାତ୍ର ମୁଖ୍ୟ ଆଲୋଚକ ଭାବେ ଯୋଗଦେଇ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ସଂପର୍କରେ ବିଶଦ ଭାବେ ଆଲୋଚନା କରିଥିଲେ। ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠନାଥ ଭାଉଳ ଲିଖିତପ୍ରବନ୍ଧ ପାଠ କରିଥିଲେ। ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗର ଛାତ୍ର/ଛାତ୍ରୀ ସନ୍ଦୀପ ବେହେରା, କ୍ଷୀରୋଦ ସେଠୀ, ଅର୍ଚ୍ଚନା ମଲ୍ଲିକ, ସୁକଲ୍ୟାଣୀ ବେହେରା, ଜ୍ୟୋତ୍ସ୍ନାରାଣୀ ଦେ, ନିବେଦିତା ପାତ୍ର, ବିଶ୍ୱରଞ୍ଜନ ସାହୁ, ବିଜୁଦତ୍ତ ପଣ୍ଡା, ବର୍ଷାରାଣୀ ସାହୁ ପ୍ରମୁଖ ଆଲୋଚନାରେ ଭାଗ ନେଇଥିଲେ। ଅଧ୍ୟାପକ ତାରାକାନ୍ତ ମହାରଣା ଧନ୍ୟବାଦ ଦେଇଥିଲେ।

Prameya



ପଦାର୍ଥ ବିଜ୍ଞାନର ଆଲୋଚନାଚକ୍ର

•ପଟ୍ଟାମୁଣ୍ଡାଇ,ପିଏନଏସ

ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ. ରମେଶ ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସମ୍ପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । କେନ୍ଦ୍ରାପଡ଼ା କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ମୁଖ୍ୟ ଭାନଚନ୍ଦ୍ର ପାତ୍ର ମୁଖ୍ୟଆଲୋଚକ ଭାବେ ଯୋଗଦେଇ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ସମ୍ପର୍କରେ ବିଶଦ ଭାବେ ଆଲୋଚନା କରିଥିଲେ । ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠନାଥ ଭାଉଳ ଲିଖିତପ୍ରବନ୍ଧ ପାଠ କରିଥିଲେ । ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗର ଛାତ୍ର/ଛାତ୍ରୀ ସନ୍ଦୀପ ବେହେରା, କ୍ଷୀରୋଦ ସେଠୀ, ଅର୍ଚ୍ଚନା ମଲ୍ଲିକ, ସୁକଲ୍ୟାଣୀ ବେହେରା, ଜ୍ୟୋତ୍ସ୍ନାରାଣୀ ଦେ, ନିବେଦିତା ପାତ୍ର, ବିଶ୍ୱରଞ୍ଜନ ସାହୁ, ବିଜୁଦତ୍ତ ପଣ୍ଡା, ବର୍ଷାରାଣୀସାହୁ ପ୍ରମୁଖ ଆଲୋଚନାରେ ଭାଗନେଇଥିଲେ ।

Pragatibadi

Departmental seminar on topic- Space Quantization & vector model published in dally odia news papers **on 05.01.2020**

ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ଆଲୋଚନାଚକ୍ର

ପଟ୍ଟାମୁଣ୍ଡାଇ,୪ା୧(ନି ପ୍ର): ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥ ବିଜ୍ଞାନ ବିଭାଗ ପକ୍ଷରୁ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ଶୀର୍ଷକ ଆଲୋଚନାଚକ୍ର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ବିଭାଗ ମୁଖ୍ୟ ଡ. ରମେଶ କୁମାର ସାହୁ ସ୍ୱାଗତ ଭାଷଣ ଦେଇ କାର୍ଯ୍ୟକ୍ରମ ସଂପର୍କରେ ସୂଚନା ଦେଇଥିଲେ। କେନ୍ଦ୍ରାପଡ଼ା କଲେଜ ପଦାର୍ଥବିଜ୍ଞାନ ମୁଖ୍ୟ ଭାନଚନ୍ଦ୍ର ପାତ୍ର ମୁଖ୍ୟଆଲୋଚକ ଭାବେ ଭେକ୍ଟର ମଡେଲ ଓ ସ୍ପେସ କ୍ୱାଣ୍ଟାଇଜେସନ ସଂପର୍କରେ ଆଲୋଚନା କରିଥିଲେ। ଅଧ୍ୟାପକ ବୈକୁଣ୍ଠନାଥ ଭାଉଳ ଲିଖିତପ୍ରବନ୍ଧ ପାଠ କରିଥିଲେ। ପଦାର୍ଥବିଜ୍ଞାନ ବିଭାଗର ଛାତ୍ର/ଛାତ୍ରୀ ସନ୍ଦୀପ ବେହେରା, କ୍ଷୀରୋଦ ସେଠୀ, ଅର୍ଚ୍ଚନା ମଲ୍ଲିକ, ସୁକଲ୍ୟାଣୀ ବେହେରା, ଜ୍ୟୋତ୍ସ୍ନାରାଣୀ ଦେ, ନିବେଦିତା ପାତ୍ର, ବିଶ୍ୱରଞ୍ଜନ ସାହୁ, ବିଜୁଦତ୍ତ ପଣ୍ଡା, ବର୍ଷାରାଣୀ ସାହୁ ପ୍ରମୁଖ ଆଲୋଚନାରେ ଭାଗ ନେଇଥିଲେ। ଅଧ୍ୟାପକ ତାରାକାନ୍ତ ମହାରଣା ଧନ୍ୟବାଦ ଦେଇଥିଲେ।

Departmental seminar on topic- Space Quantization & vector model published in dally odia news paper **Samaj on 05.01.2020**

Department of Physics, Pattamundai College.

Students Attendance on the seminar

"Space Quantisation in Vector Model" on Dt. 21.11.2019

Sl.No.	Roll No.	Signature of the Student
1	BS19 -103	Basudev padhi
2	BS19 -117	Aurobinda Jena
3	BS19 - 047	Akash Rout
4	BS(P)-19-002	Rajesh Kumar Rout
5	BS(P)-19-115	Aditya Narayan Rout.
6	BS(P)-19-16	Pravat Kumar Biswal
7	BS(P) 19-082	Nishikanta Das
8	BS(P) 19 - 110	Smita Prakash Biswal
9	BS(P)-19-067	Ritik ranjan Patra
10	BS(P)-19-063	Akash Jena
11	BS(P)-19-062	Sujit Samal
12	BS18 - 062	Satyajit Mallick
13	BS(P) -19-104	Rajendra Ku. Swain
14	BS-17 -109	Ajit Kumar [illegible]
15	BS-17 -113	Surya kanta Dash
16	BS-18-090	Prajnananda Ray
17	BS-18-072	Pradeep kumar Dash
18	BS-18-102	Bibek Behera
19	BS-18-050	Suvam Lenka
20	BS-18-034	Kalipada Giri
21	BS-17-120	Nibedita Patra
22	BS-17-150	Silpa rani Das
23	BS17 - 79	Sandeep Ku. Behera
24	BS17 - 136	Jainyasenee Das
25	BS17 - 114	Archana Mallick
26	BS17-129	Bijayalaxmi Sarangi
27	BS17-007	Nowsad Khan
28	BS17 - 146	Janmejay Pradhan
29	BS17 - 128	Sukhakanti Behera.
30	BS17 - 032	Laxmipriya sahoo
31	BS18 - 131	Bhagyashree Mohanty

32	BS18-109	Bibhudatta Panda
33	BS18-088	Sunanda Sahoo
34	BS18-055	Sarojini Jena
35	BS19-072	Sushree Sucharita Mohanty
36	BS19-090	Mirarani Rout.
37	BS19-014	Srutisudha Mishra
38	BS-18-133	Barsharani Sahoo
39	Bs-18-119	Sanjita Behera
40	BS-18-076	Dipika rani Dash
11	BS-19-099	Amisha Panda
42	BS-19-111	Bhagyashree Rout
43	BS-19-105	Smrutirekha Das
44	BS-19-30	Asima Nath.
45	BS-19-074	Rasmita Gain
46	BS-17-138	Khirod Ku. Sethi
47	BS-17-133	Niranjan Das
48	BS-17-064	Srinibash Sahoo
49	BS-18-085	Sujit Kumar Swain
50	BS-17-155	Biswaranjan Sahoo
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Photo gallery

A SEMINAR

ON

“TRIBOELECTRIC NANOGENERATOR”

Presented by:

Mr.Biswaranjan Puhan
Reader in Physics Kendrapara
Autonomous College, Kendrapara.

On

23rd Nov 2019

DEPARTMENT OF PHYSICS

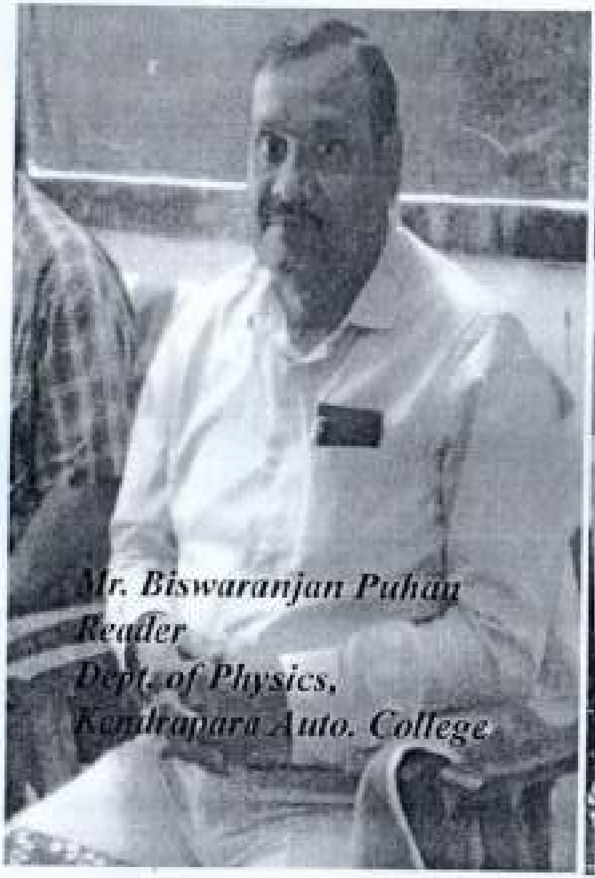
PATTAMUDAI COLLEGE,

PATTAMUNDAI.

REPORT

A seminar was organised by Department of Physics, Pattamundai College, pattamundai on 23.11.2019 on the topic "Triboelectric Nanogenerator". Mr. Biswaranjan Puhan, Reader in Physics Kendrapara Autonomous College, Kendrapara, was the resource person for the seminar. In this seminar, Dr Ramesh Kumar Sahoo, Head of the Department chaired the meeting and welcomed the guests on the dais as well as participants .Mr. Tarakanta Maharana gave a key note of the topic. The meeting was ended with vote of thanks by Mr. Baikunth Charan Roul, another faculty member.

TRIBOELECTRIC NANOGENERATOR



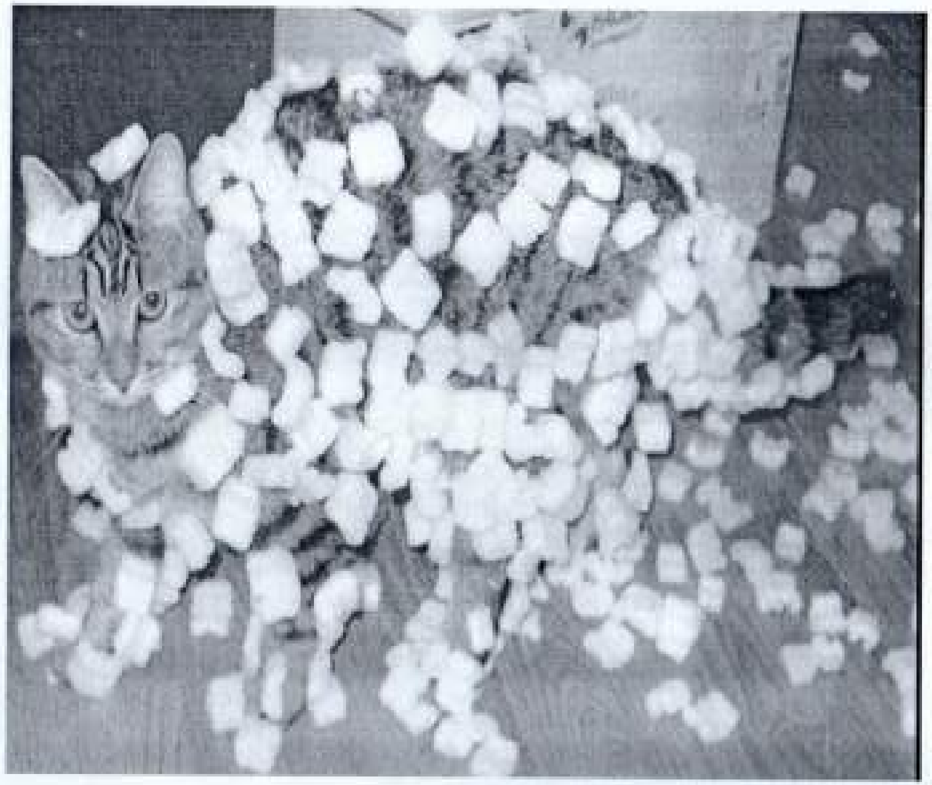
Mr. Biswaranjan Puhan
Reader
Dept. of Physics,
Kendrapara Auto. College

Outline

- *Introduction*
- *Motivation*
- *Theoretical Explanation*
- *Triboelectric Nanogenerator*
- *Strategies to Improve the Triboelectric Charge Densities*
- *Application*
- *Challenges*

Introduction

- *Tribo(rub)+Electricity*
- *Greek philosopher noticed first*
- *Everyday Examples*
    - ➢*Glass rubbed with silk*
    - ➢*Hard rubber rubbed with fur*
    - ➢*Rubbing comb through hair etc.*
- *Polarity and strength depends upon*
    - ➢*Type of material*
    - ➢*Surface roughness*
    - ➢*Temperature*
    - ➢*Strain etc.*

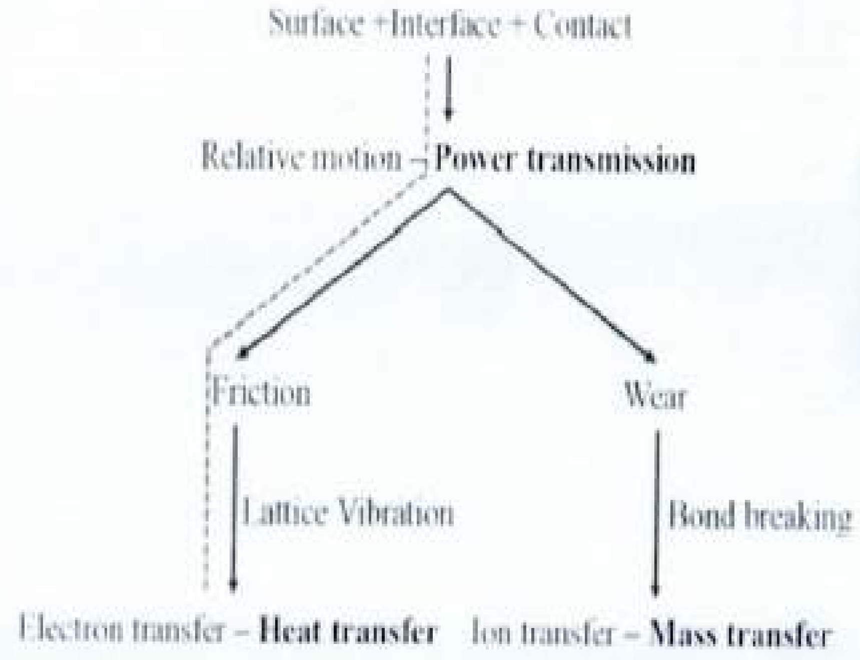


Motivation

- *No energy-No life*
- *Some basic reasons to look for green energies are*
    - *Depletion of conventional resources*
    - *Environmental impact*
    - *Waste generation*
- *As a country, we have the potential to be self sufficient, removing the need to import energy from abroad.*

Theoretical Explanation

- *Tribology is an interfacial phenomenon coupled with*
  - *Mechanics*
  - *Thermodynamics*
  - *Electromagnetism etc.*
- *Some essential questions need to be answered*
  - *What are the driving forces?*
  - *Where do they come from?*
  - *Why don't the charges go on accumulating?*



Surface +Interface + Contact

Relative motion – **Power transmission**

Friction

Wear

Lattice Vibration

Bond breaking

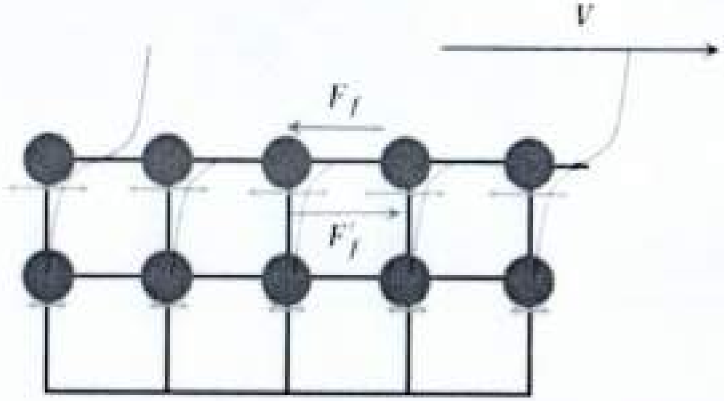
Electron transfer – **Heat transfer**

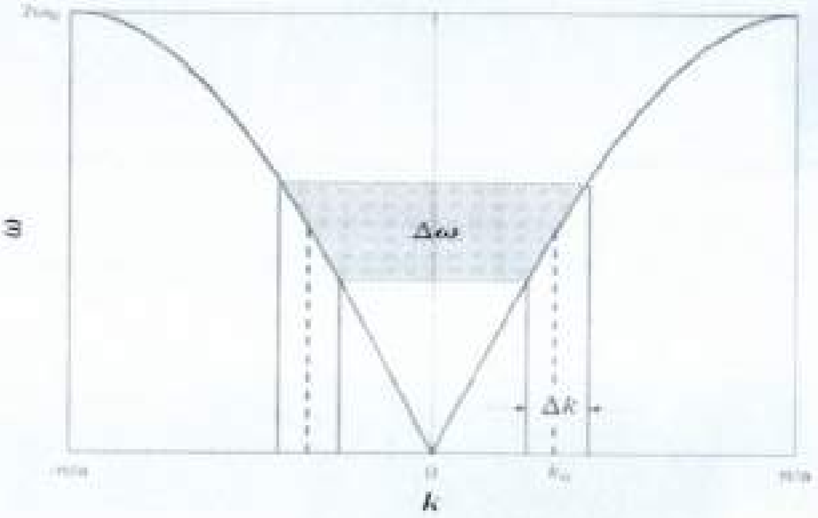
Ion transfer – **Mass transfer**

Pan et al. J. Appl. Phys. ***122****, 144302 (2017)*

- *Normal force of 1MPa and a velocity of 1m/s can produce heat flux of magnitude*

  $\sim 10^{-5} - 10^{-6} \frac{J}{m^2 \cdot s}$
- *The deformed lattice vibrate back in a damping mode.*
- *This damping can trigger scattering of electrons*
- *Extended phonon modes have higher energy than the equilibrium once.*
- *Phonons provide the surface energy to the electrons.*
- *A capacitive layer is formed on the accepter surface.*





Pan et al. J. Appl. Phys. ***122****, 144302 (2017)*

- *The charge density on the dielectric surfaces, calculated using the model is given in the table.*

Material Pair	Charge Density(C/m^2)
Cr-Cr	2.02×10^{-8}
Cr-Steel	3.37×10^{-8}
Metal-Quartz	10^{-5}
Metal-Nylon	10^{-3}
Metal-PTFE	$10^{-4} - 10^{-3}$

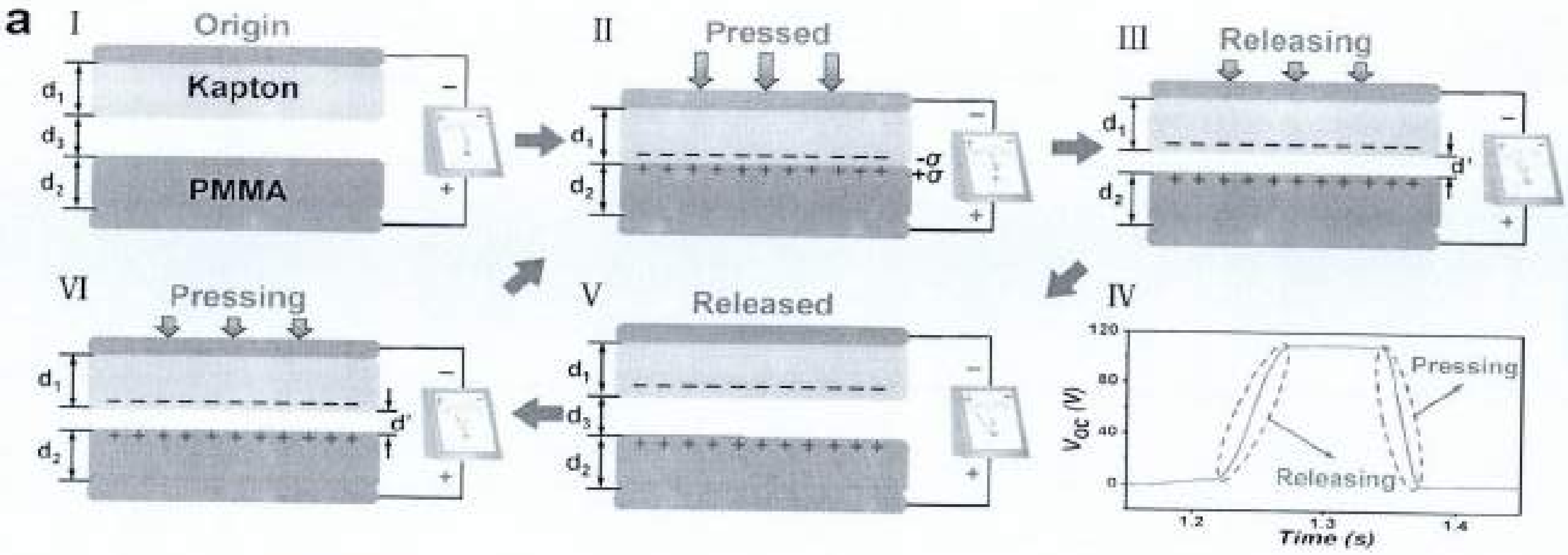
Pan et al. J. Appl. Phys. ***122****, 144302 (2017)*

Triboelectric Nanogenerator

- *What is a nanogenerator?*
- *A nanogenerator has three typical approaches*
    - ➢*Pyroelectric*
    - ➢*Piezoelectric*
    - ➢*Triboelectric*
- *The first triboelectric nanogenerator was designed in 2012.*
- *It can generate AC output.*

Working

Vertical Separation Mode



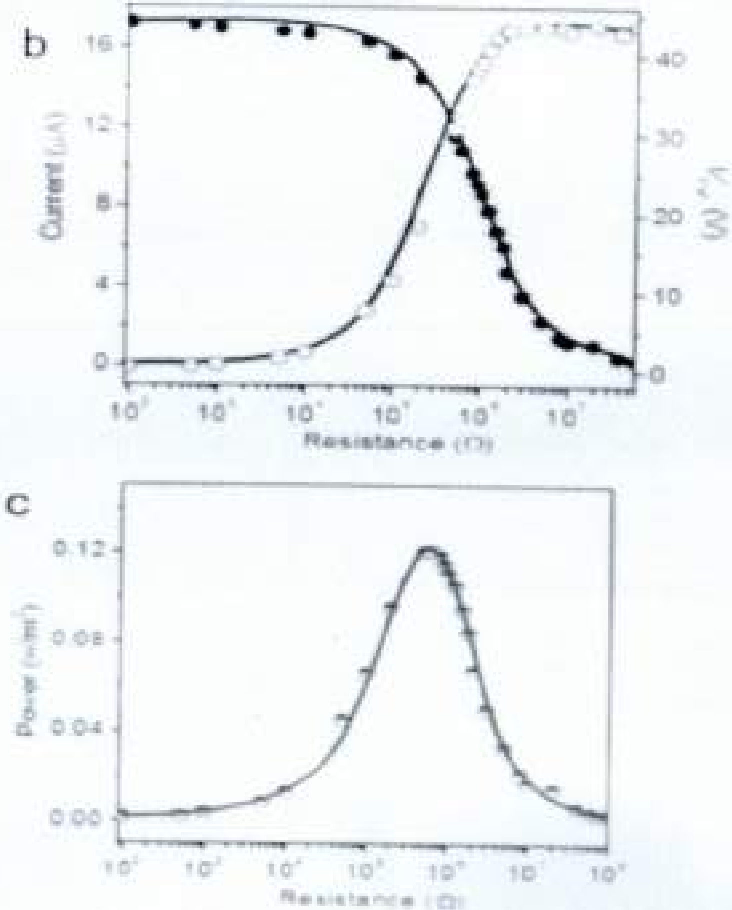
$$U = -\frac{\sigma d_3}{\varepsilon_0}$$

PMMA-Polymethyl methacrylate

Maximum Efficiency-9.6%

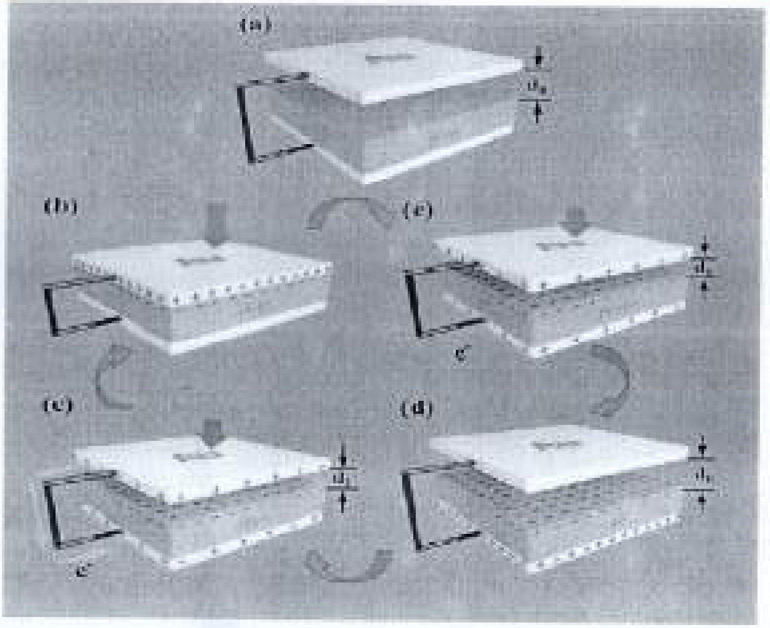
Y Wang et al.

- *The variation of current, voltage output, and power output with the load resistance,for a triboelectric nanogenerator developed in Prof. Wang's lab is shown in the figure.*



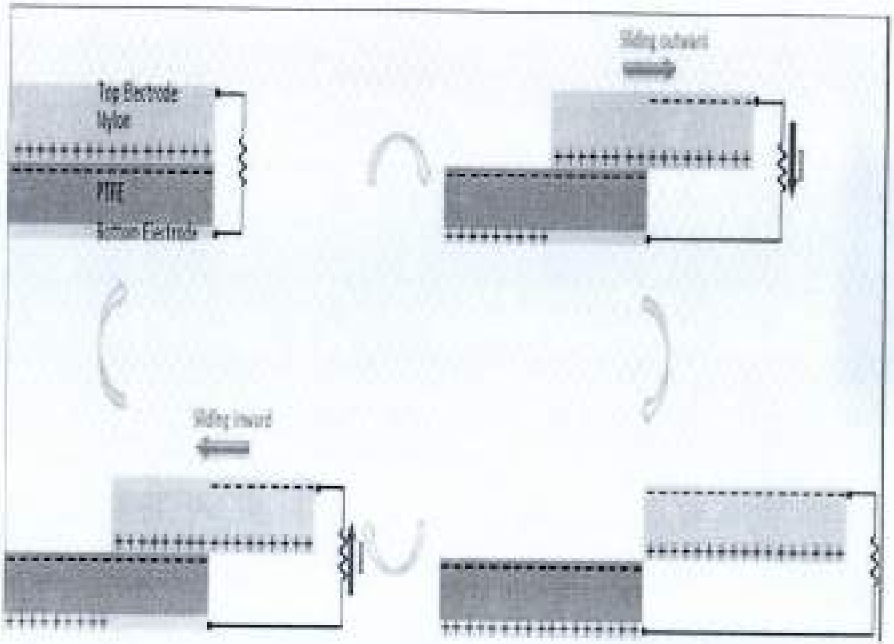
Different Modes

Single Dielectric Mode



PDMS-Polydimethylsiloxane
ITO-Indium tin oxide

Lateral Sliding Mode



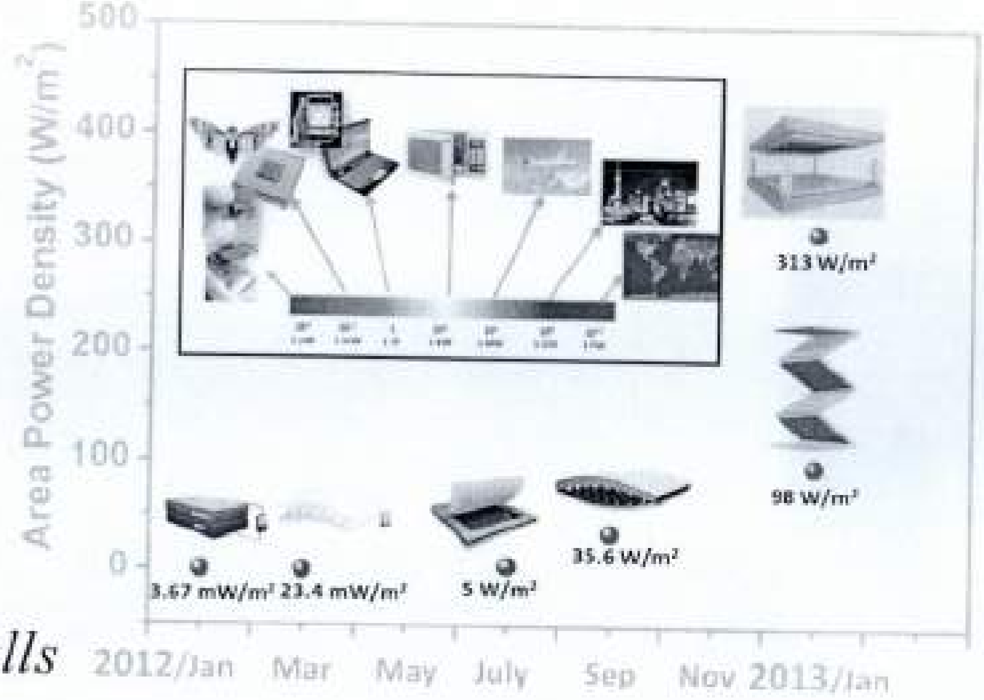
Wu et al.

Strategies to Improve the Triboelectric Charge Densities

- *Mainly three strategies*
    - ➢*Modification in material composition*
    - ➢*Improvement in effective contact area*
    - ➢*Change in environmental condition*
- *The material modification strategy can be further modified into*
    - ➢*Chemical surface functionalization*
    - ➢*Bulk composition manipulation*

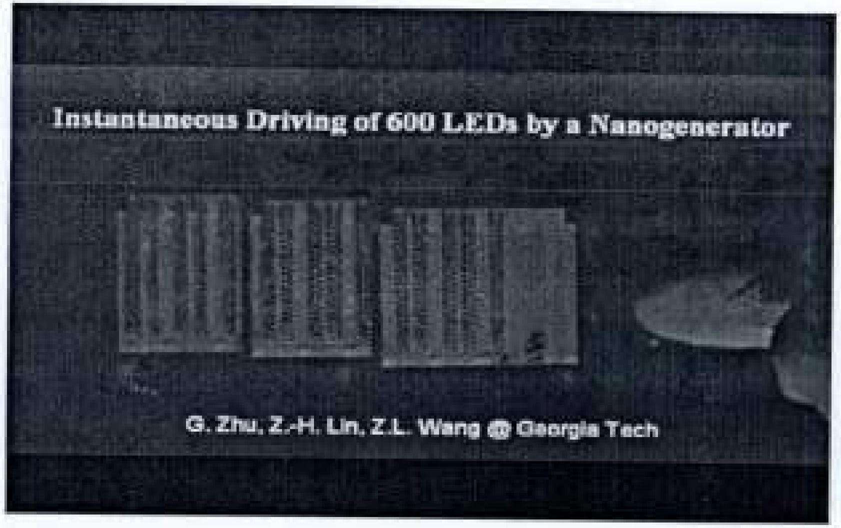
Applications

- *Energy harvesting, aiming at powering micro or nano systems.*
- *Medical Science*
- *Personal electronics*
- *Self powered motion sensors*
- *Possible to scale up this type of technology at a large scope such as with rolling wheels, human foot falls at streets, ocean waves etc.*



For a human footfall force of 500 – 600 N

- ➢Maximum $I = 2\ mA$
- ➢Instantaneous_current $= 1.1 mA$ at a load of $1\ M\Omega$,
- ➢Instantaneous output power $= 1.2\ W$
- ➢power density $= 313\ W/m^2$
- ➢Maximum triboelectric charge density $= 594.2\ \mu C/m^2$
- ➢Maximum device efficiency $= 9.8\%$



Instantaneous Driving of 600 LEDs by a Nanogenerator

G. Zhu, Z.-H. Lin, Z.L. Wang @ Georgia Tech

Challenges

- *Theory is not complete.*
- *Quantum theory of triboelectric effect.*
- *Quantification of triboelectric series.*
- *Low conversion efficiency.*
- *Contact problems need to be solved.*

Challenges

- *Theory is not complete.*
- *Quantum theory of triboelectric effect.*
- *Quantification of triboelectric series.*
- *Low conversion efficiency.*
- *Contact problems need to be solved.*

23/11/19

References

1. *Zhu et al. Nano Lett.,* ***13****, 847–853 (2013)*
2. *Pan et al. J. Appl. Phys.* ***122****, 144302 (2017)*
3. *Zhu et al. Nano Lett.,* ***12****, 4960–4965 (2012)*
4. *Wu et al. Adv. Energy Matter.,****9****,1802906(2019)*

ପଦାର୍ଥବିଜ୍ଞାନ ପକ୍ଷରୁ ଆଲୋଚନାଚକ୍ର

Departmental seminar on topic- Triboelectric nano generator published in dally odia news paper **Nitidin on 14.01.2020**

ପଟ୍ଟାମୁଣ୍ଡାଇ କଲେଜ ପକ୍ଷରୁ ଆଲୋଚନାଚକ୍ର

Departmental seminar on topic- Triboelectric nano generator published in dally odia news paper **Samaj on 14.01.2020**

Department of Physics, Pattamundai College.

Students Attendance on the seminar

"Tribo-Electric Nanogenerator" on Dt. 23.11.2019

Sl.No.	Roll No.	Signature of the Student
1	BS17-109	Adit Kumar Chauhan
2	BS17-032	Laxmipriya sahoo
3	BS17-150	Silparani Das
4	BS17-007	Nousad Khan
5	BS17-136	Jajnyajenee Das
6	BS17-117	Deepali Sahoo
7	BS17-114	Archana Mallick
8	BS17-129	Bijayalaxmi Sarangi
9	BS17-064	Srisibash sahoo
10	BS17-128	Subhakant Behera.
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26	BS19-105	Swarnarekha Das
27	BS19-019	Amisha Panda
28	BS 19-030	Asima Nath
29	BS-19-072	Sushree sucharita Mohanty
30	Bs-19-074	Rasmita Gain
31	BS-19-111	Bhagya Shree Rout

32	BS19-090	Mirarani Raut.
33	BS19-014	Sruticudha Mishra.
34	BS-18-102	Bibek Behera
35	BS-18-050	Suvam Lenka
36	BS-18-034	Kalipada Giri
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42	BS-18-030	Satya narayan patra
43	BS-18-021	Soumya Ranjan Behera
44	BS-19-062	Sujit Samal.
45	BS-19-067	Ritik Ranjan Patra
46	BS-19-104	Rajendra Kr. Swain
47	BS(P)19-084	Nishikanta Das
48	BS(P)19-016	Pravat Kumar Biswal
49	BS(P)-19-115	Aditya Narayan Rout.
50	BS(P)-19-009	Rajesh Kumar Raut
51	BS(P)-19-063	Akash Jena
52	BS(P)-19-047	Akash Rout
53	BS(P)-19-110	Smita Prakash Biswal
54	BS19-103	Basudev Padhi
55	BS-18-085	Sujit Kumar Swain.
56	BS-18-109	Bibhudatta Panda-
57	BS-18-123	Barsharani Sahoo
58	BS19-055	Sarojini Jena
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A SEMINAR

ON

"LASER"

Presented by:

Mr. Ranjeet Kumar Das
Lecturer in Physics Kendrapara
Autonomous College, Kendrapara.

On

25th Feb 2019

DEPARTMENT OF PHYSICS

PATTAMUDAI COLLEGE,

PATTAMUNDAI.

REPORT

A seminar was organised by Department of Physics, Pattamundai College, pattamundai on 25.02.2019 on the topic "LASER". Mr. Ranjeet Kumar Das, Lecturer in Physics Kendrapara Autonomous College, Kendrapara was the resource person for the seminar. In this seminar Mr. Ramesh Chandra sahoo, principal, chaired the meeting .Mr.Bijay Kumar Mohanty, Head of the Department in political science was the guest of honour.. Dr Ramesh Kumar Sahoo Head of the Department gave a key note address of the topic and welcomed the guests on the dias as well as participant. The meeting was ended with vote of thanks by Mr. Tarakanta Maharana, another faculty member.

****

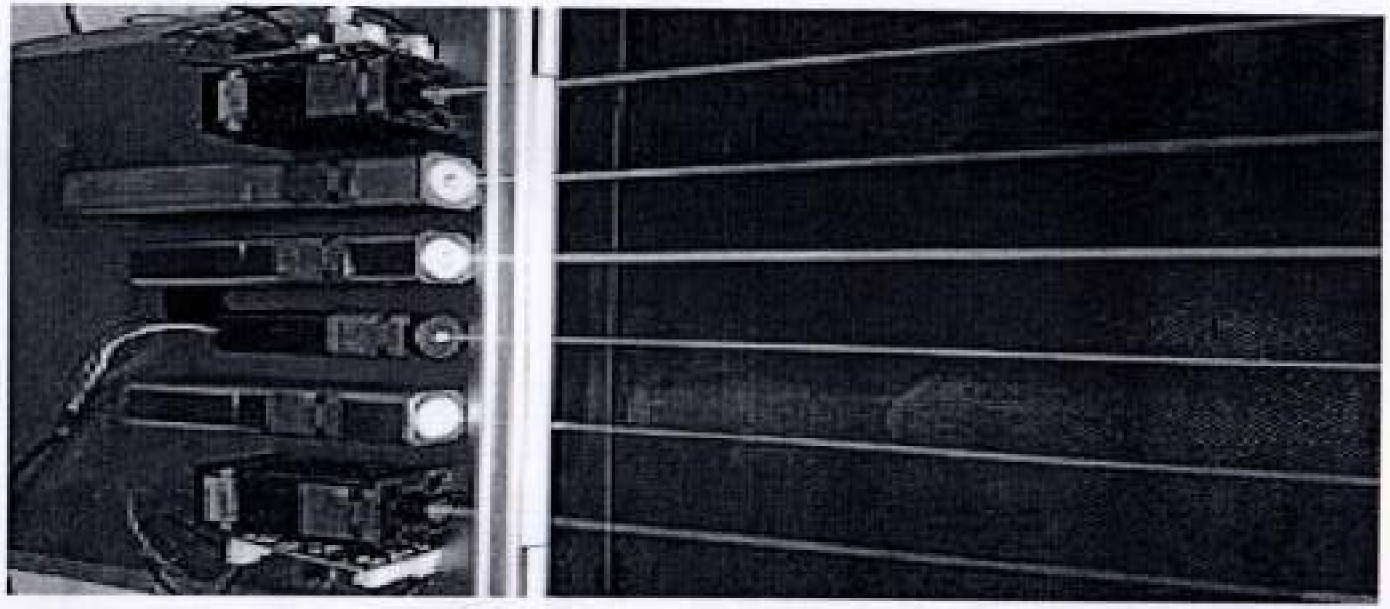
INTRODUCTION TO LASER

by

Ranjeet Kumar Das

Lecturer in Physics Gr.-A

Kendrapara Autonomous College , Kendrapara

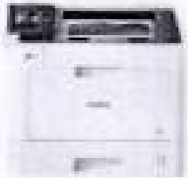


INTRODUCTION

- Outstanding invention of 20th century.
- A Laser is a device that emits through optical amplification based on stimulated emission of radiation.
- Laser is an acronym for " Light Amplification by Stimulated Emission of Radiation"
- The first Laser was built in 1960 by Theodre H. Maiman
- A Laser emits light coherently
- Spatial coherence allows light to be focussed to a tight spot also to stay narrow(collimation)
- Temporal coherence allows Laser to emit light with a very narrow spectrum(single colour)

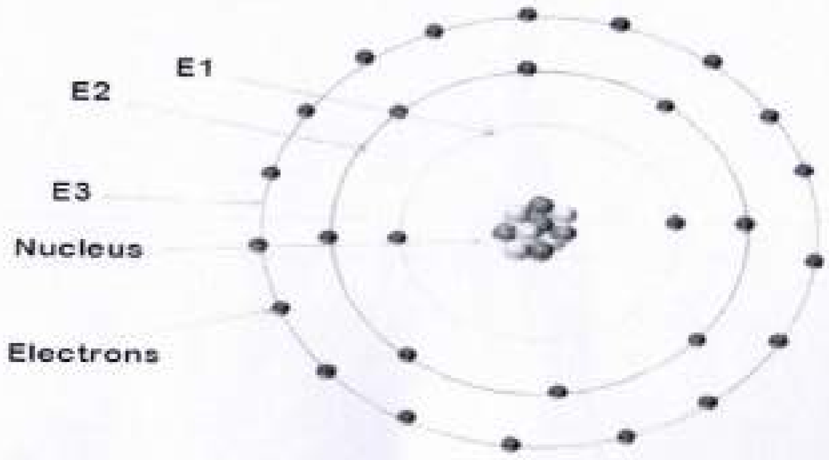
APPLICATION

- Laser printer
- Laser surgery
- Cutting and welding material
- Military



ENERGY LEVELS OF ELECTRONS

- The electrons revolving around the nucleus have different energy levels based on the distance from the nucleus.
- The electrons revolving very close to the nucleus have lowest energy level and the farthest distance from nucleus have highest energy level.



Physics and Radio Electronics

Thermodynamic Equilibrium

The ratio of the number of atoms at two energy levels (1 and 2) under thermodynamic equilibrium is given by the following equation:

$$\mathbf{N_2/N_1 = exp[- (E_2 - E_1) / kT]}$$

where **N(1)** and **N(2)** are the number of atoms in level 1 and level 2, respectively, **E(1)** and **E(2)** are the energies of the two levels, **k** is the Boltzmann constant, and **T** is the temperature in kelvins

INTERACTION OF PHOTON

The photons interact in three ways with the atoms:

- Absorption of radiation or light
- Spontaneous emission
- Stimulated emission

ABSORPTION OF RADIATION

The light or photons energy applied to excite the electrons can be mathematically written as

$h\nu = E_2 - E_1$

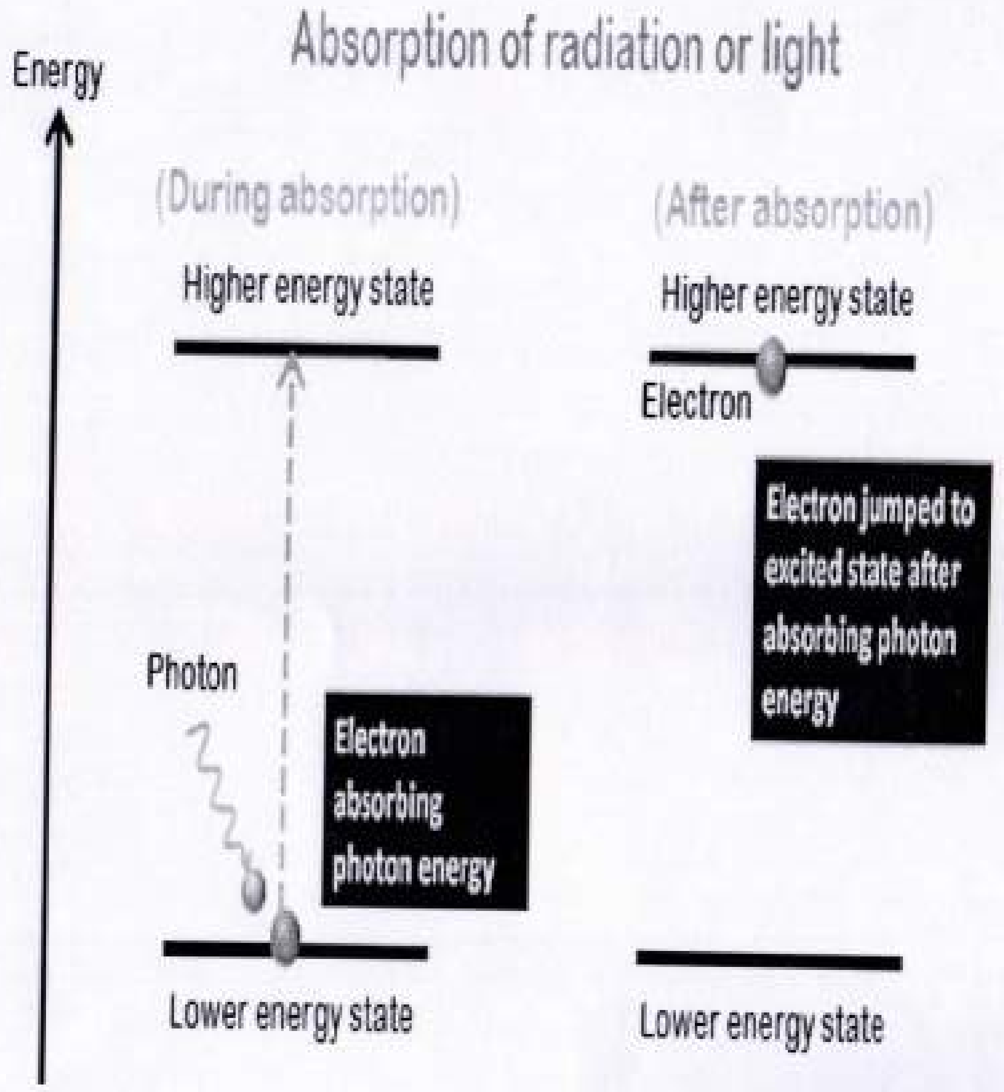
Where h = Planck's constant

V = Frequency of photon

E_1 = Lower energy level electrons or ground state electrons

E_2 = Higher energy level electrons or excited state electrons

❖Absorption occurs only if the energy of photon exactly matches the difference in energy between the two electron shells or orbits.

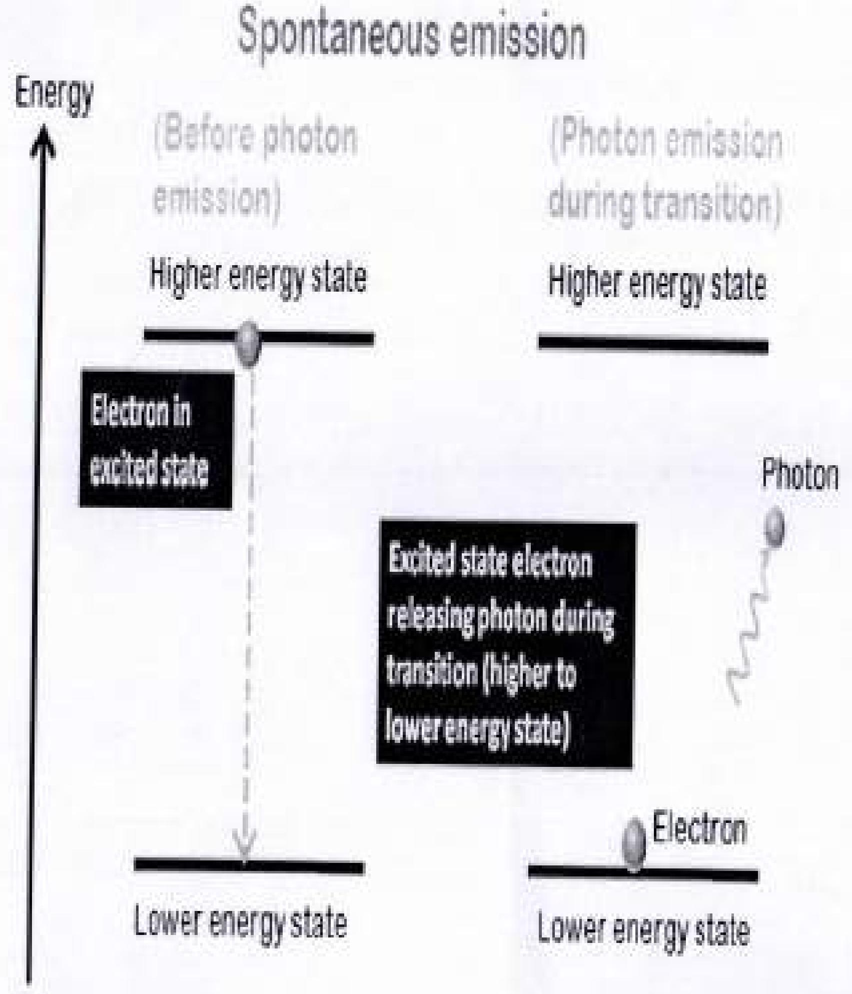


Physics and Radio-Electronics

Spontaneous emission

- The process by which excited electrons emit photons while falling to the ground level or lower energy level is called spontaneous emission.

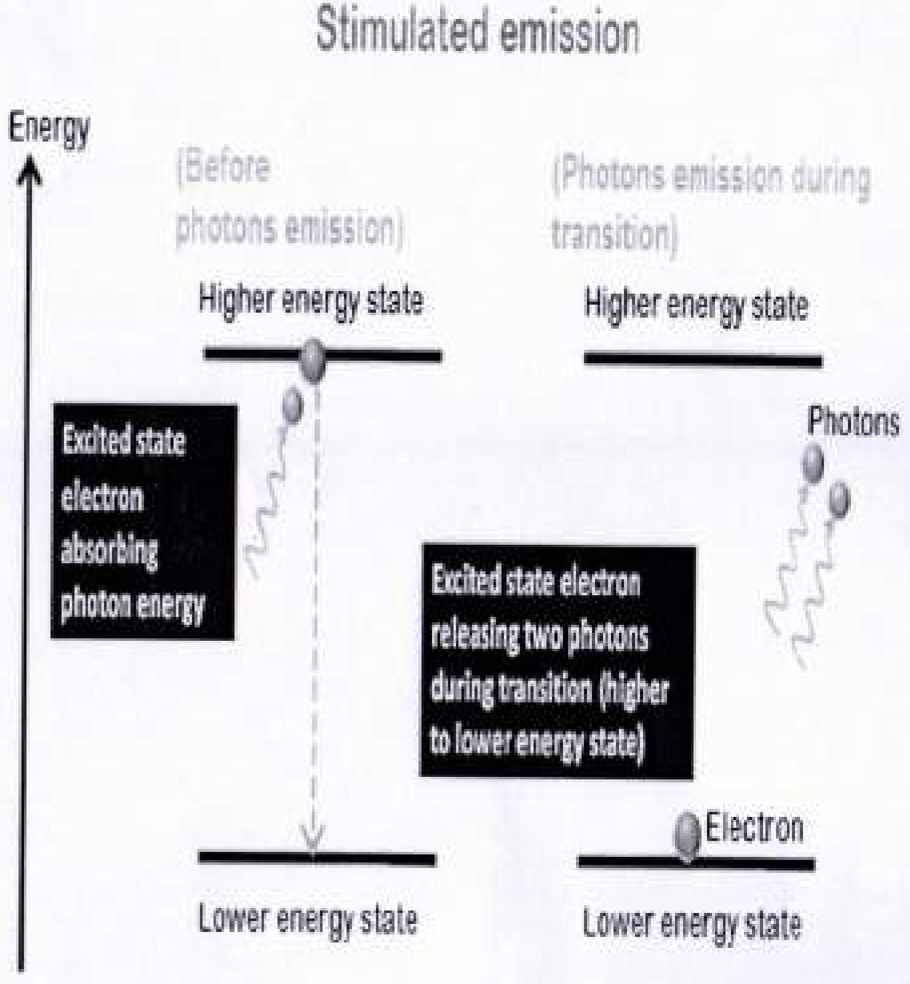
- The electrons in the excited state do not stay for a long period because the lifetime of electrons in the higher energy state or excited state is very small, of the order of 10^{-8} sec. Hence, they fall back to the ground state by releasing energy in the form of photons or light.



Physics and Radio-Electronics

STIMULATED EMISSION

- The process by which electrons in the excited state are stimulated to emit photons while falling to the ground state or lower energy state is called stimulated emission.
- The light energy or photon energy is supplied to the excited electrons instead of supplying energy to the ground state electrons.
- The stimulated emission is not a natural process it is an artificial process. In stimulated emission, the electrons in the excited state need not wait for natural spontaneous emission to occur. An alternative method is used to stimulate excited electron to emit photons and fall back to ground state.



Physics and Radio-Electronics

CHARACTERISTICS OF STIMULATED EMISSION

- One photon can produce 2^n photons after n times stimulation.
- Induced photon has the same frequency, phase & plane of polarization as those of stimulating one
- The light waves due to all photons are coherent and thus interfere constructively and get amplified
- The net Intesity, $I_{Total} = N^2 I$

Where, N – number of atoms radiating light

I – Intensity of light emitted by one atom

PRE-REQUISITES FOR LASER

- An active medium (when exited supports population inversion)
- Pumping mechanism to be ensured
- Optical resonant cavity (to increase photon density)
- Metastable state (exited state having longer life time)

PRINCIPAL PUMPING SCHEME

Three-Level and Four-Level Laser Energy Diagrams

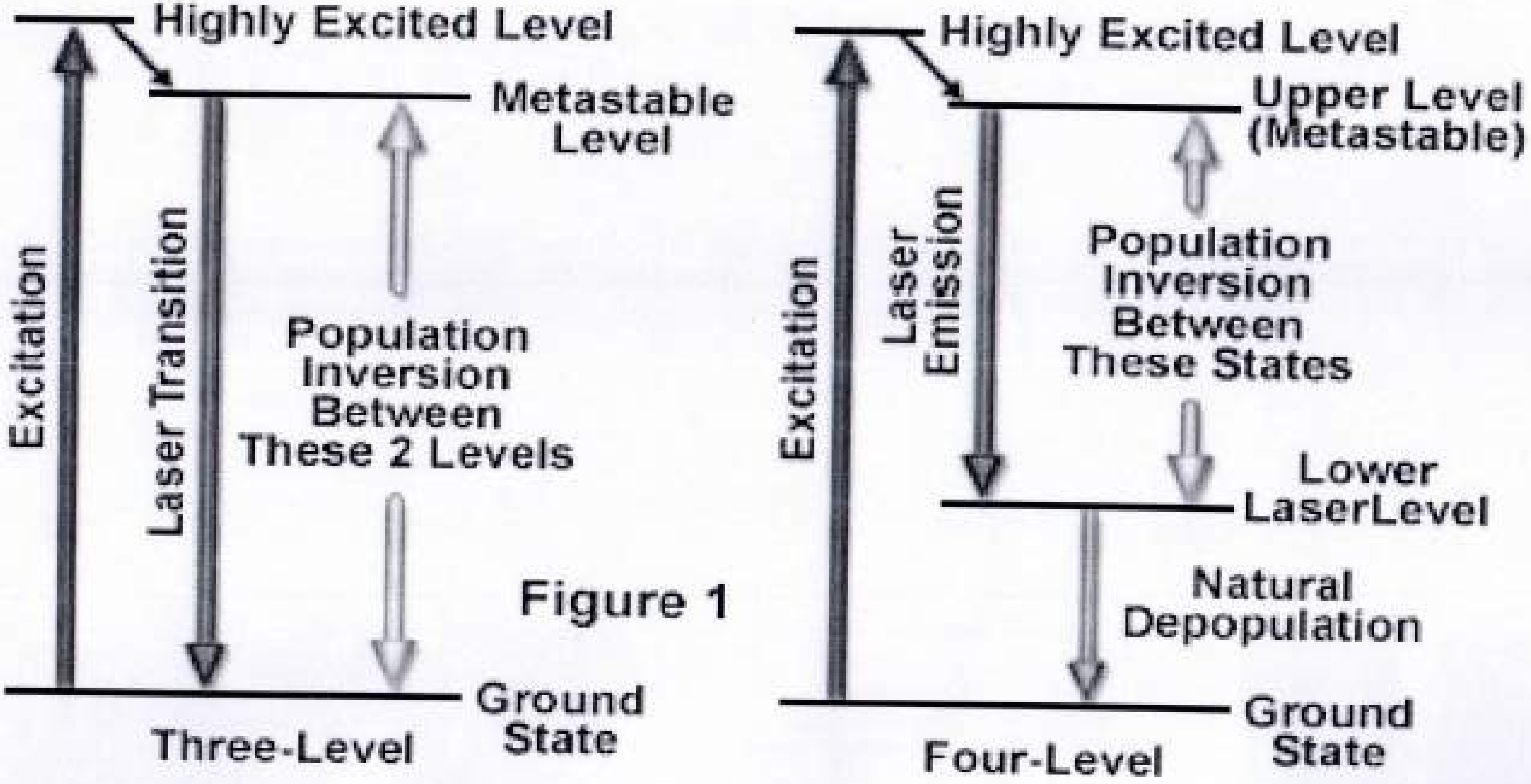
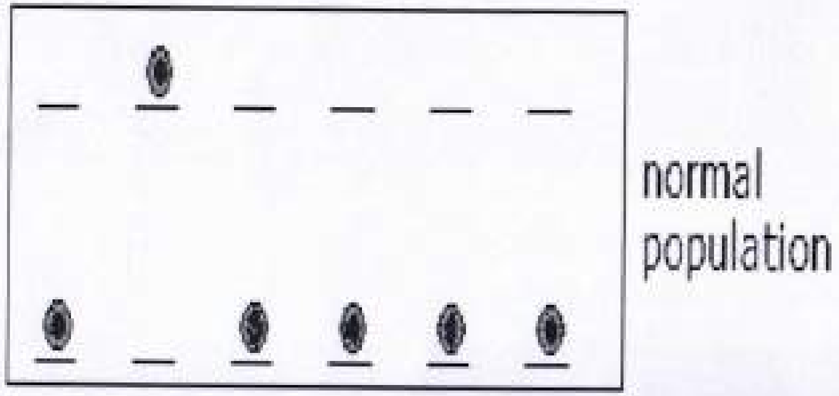
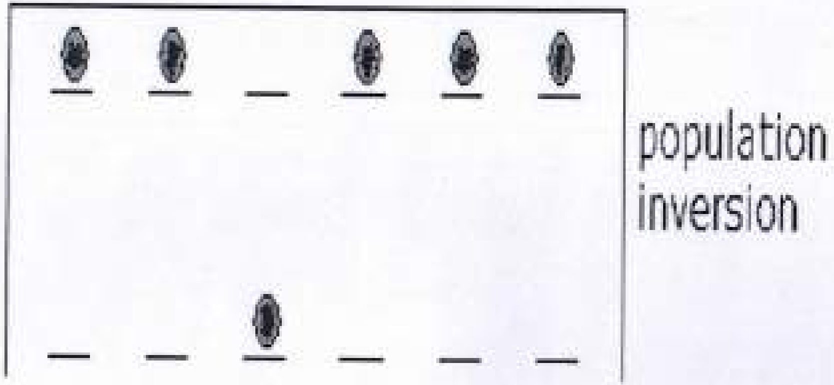


Figure 1

Population inversion

- Population inversion is the non-equilibrium condition of the material in which($N_2 >> N_1$)





PUMPINIG

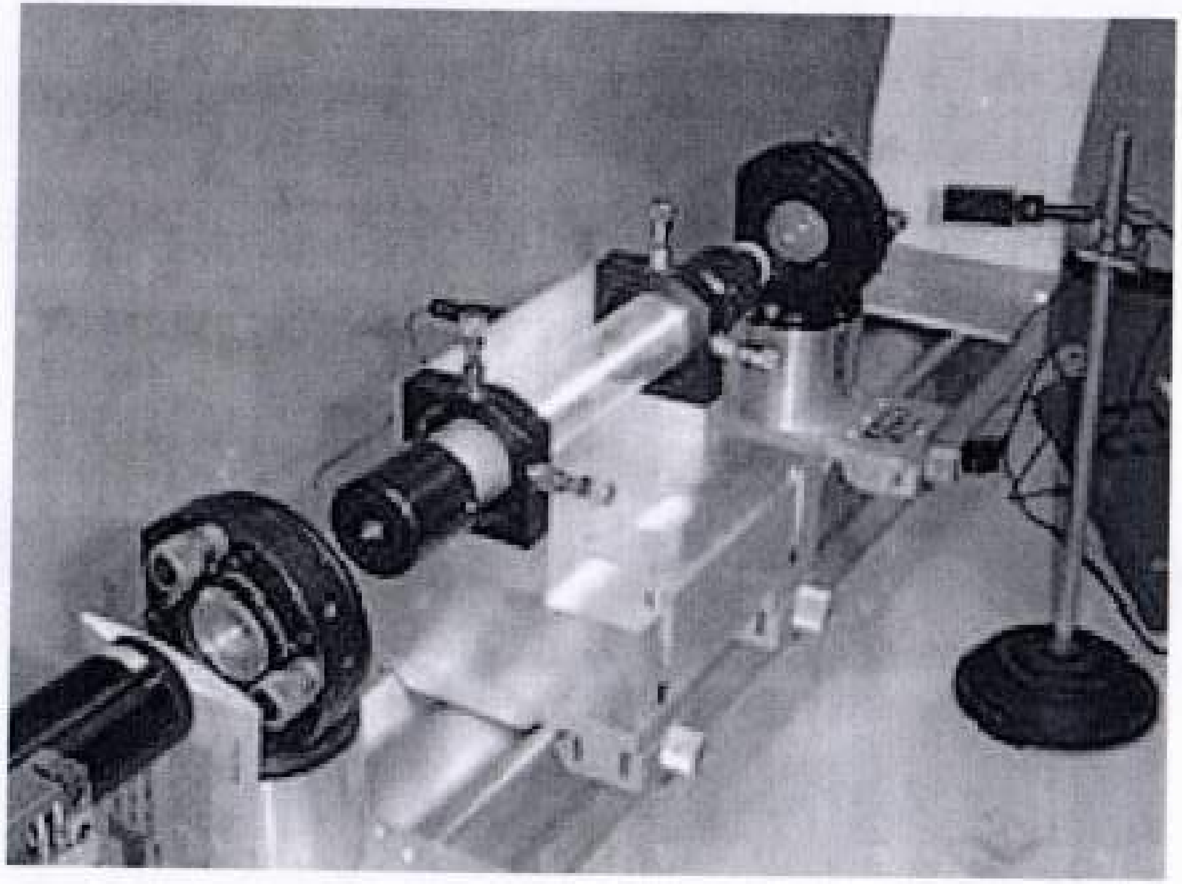
Process of supplying energy to the laser medium for population inversion.

Several ways of pumping

- Optical pumping (short flash of light)
- Inelastic atomic collision
- Electric discharge
- Direct conversion (electric energy to light in LED)

TYPES OF LASERS

Types	**Examples**
• Solid state Lasers	• Ruby laser- 3 level
• Gas Lasers	• He-Ne laser – 4 level
• Liquid Lasers	• Dye Laser
• Semiconductor diode Lasers	• Gallium- Arsenide (direct band gap semiconductor)



He-Ne Laser

Invented in 1961 A. Javan, W.R. Bennet, D.R.Herriot

Thank You

Ranjeet Kumar Dey

Department of Physics, Pattamundai College, Pattamundai

Students Attendance on the seminar"LASER" on 25.02.2019

Sl No	Roll No	Signature of the Student
1	BS-18-109	Bibhudatta Panda
2	BS-17-133	Niranjan Das
3	BS-17-154	Subhakanta Lenka.
4	BS-17-079	Sandeep Kumar Behera.
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15	BS-18-58	Madhusudan Behera
16	BS-16-021	Soumya Ranjan Behera
17	BS-16-024	Dilip Das
18	BS16-048	Subham Kumar Lenka.
19	BS16-004	Shivasini Sahoo
20	BS16-133	Manisha Parida
21	BS16 -135	Sonali Sahoo
22	BS16 -134	Sonu Patra
23	BS-16-130	Monalisa Rout
24	BS16-129	Swapnarani Panda
25	BS-16-146	Priyanka Rout
26	BS-16-147	Tanushree. Parida
27	BS-17-120	Nibedita Patra
28	BS-16-102	Rasmita Swain.
29	BS16-001	Swatiprava Sahoo
30	BS16-014	Debasmita Bhuyan
31	BS16-045	Satyabati Sahoo
32	BS16-106	Arpita Priyadarshani Rout
33	BS17-032	Laxmipriya Sahoo

34	BS16-156	Susmita Sahoo
35	BS17-136	Tajnyasenee Das
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37	BS17-114	Archana Mallick
38	BS-17-117	Deepali Sahoo
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A SEMINAR

ON

"HISTORICAL INTRODUCTION TO QUANTUM MECHANICS"

Presented by:

Mr.Rama Chandra Patra
Reader in Physics Kendrapara
Autonomous College, Kendrapara.

On

14th March 2019

DEPARTMENT OF PHYSICS
PATTAMUDAI COLLEGE,
PATTAMUNDAI.

REPORT

A seminar was organised by Department of Physics, Pattamundai College, pattamundai on 14.03.2019 on the topic "HISTORICAL INTRODUCTION TO QUANTUM MECHANICS". Mr. Rama Chandar Patra, Reader in Physics, Kendrapara Autonomous College, Kendrapara , was the resource person for the seminar.Dr Promd Kumar Samal, Head of the Department History chaired the meeting. Mr. Baikunth Charan Roul welcomed the guests on the dais and the participants . Dr Ramesh Kumar Sahoo, Head of the Department, gave a key note address of the topic. The meeting was ended with vote of thanks by Mr. Tarakanta Maharana, another faculty member.

****

Historical introduction to quantum mechanics

Gustav Kirchhoff (1824-1887)

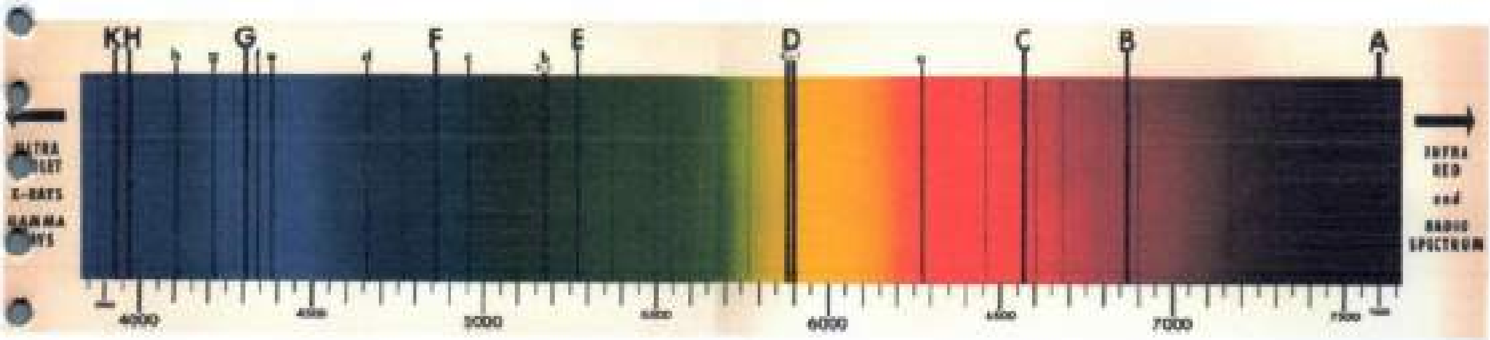
Surprisingly, the path to quantum mechanics begins with the work of German physicist Gustav Kirchhoff in 1859.

Electron was discovered by J.J.Thomson in 1897 (neutron in 1932)

The scientific community was reluctant to accept these new ideas. Thomson recalls such an incident: *„I was told long afterwards by a distinguished physicist who had been present at my lecture that he thought I had been pulling their leg".*

Historical introduction to quantum mechanics

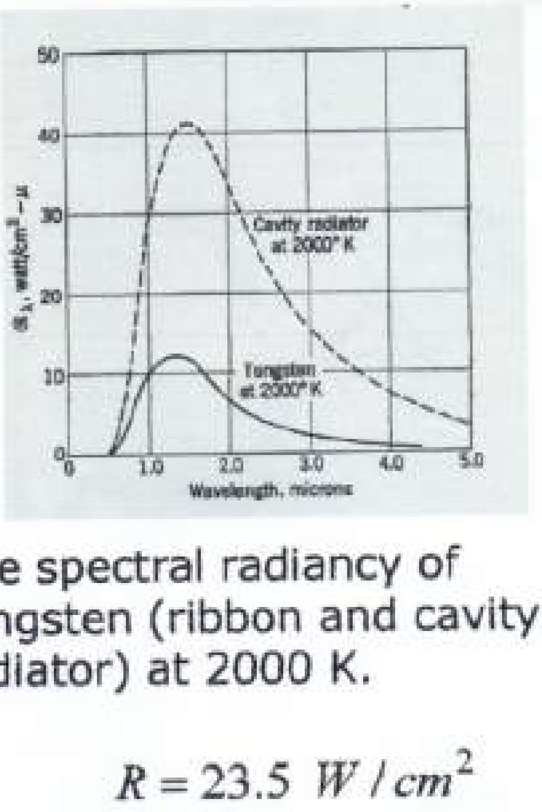
Kirchhoff discovered that so called D-lines from the light emitted by the Sun came from the absorption of light from its interior by sodium atoms at the surface.



Kirchhoff could not explain selective absorption. At that time Maxwell had not even begun to formulate his electromagnetic equations.

Statistical mechanics did not exist and thermodynamics was in its infancy

Historical introduction to quantum mechanics



The spectral radiancy of tungsten (ribbon and cavity radiator) at 2000 K.

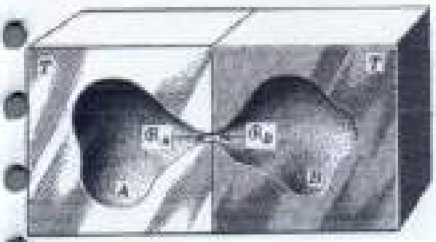
$$R = 23.5\ W / cm^2$$

- At that time it was known that heated solids (like tungsten W) and gases emit radiation.
- Spectral radiancy R_λ is defined in such a way that $R_\lambda\, d\lambda$ is the rate at which energy is radiated per unit area of surface for wavelengths lying in the interval λ to $\lambda + d\lambda$.
- Total radiated energy R is called radiancy and is defined as the rate per unit surface area at which energy is radiated into the forward hemisphere

$$R = \int_0^\infty R_\lambda d\lambda$$

Historical introduction to quantum mechanics

Kirchhoff imagined a container – a cavity –whose walls were heated up so that they emitted radiation that was trapped in the container. Within the cavity, there is a distribution of radiation of all wavelength, λ. Intensity measures the rate at which energy falls in a unit area of surface. The walls of the container can emit and absorb radiation. Intensity distribution K(λ,T) at equilibrium depends on wavelength and temperature but is independent of the properties of the material of the container and the point within container.



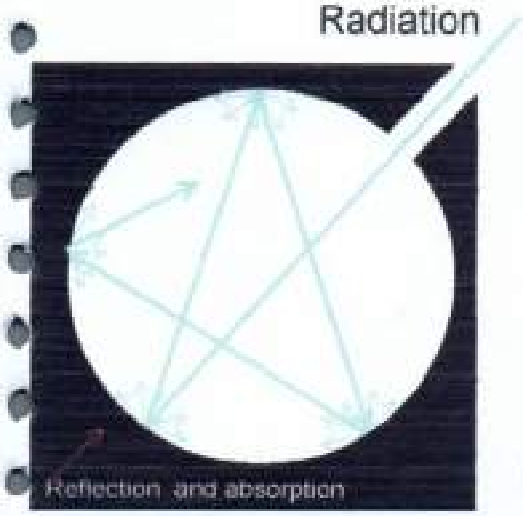
$$e_\lambda / a_\lambda = K(\lambda, T)$$

distribution function of the radiation intensity

emissivity

coefficient of absorption

Historical introduction to quantum mechanics



A small hole cut into a cavity is the most popular and realistic example of the blackbody.
⇒ None of the incident radiation escapes

What happens to this radiation?

Blackbody radiation is totally absorbed within the blackbody

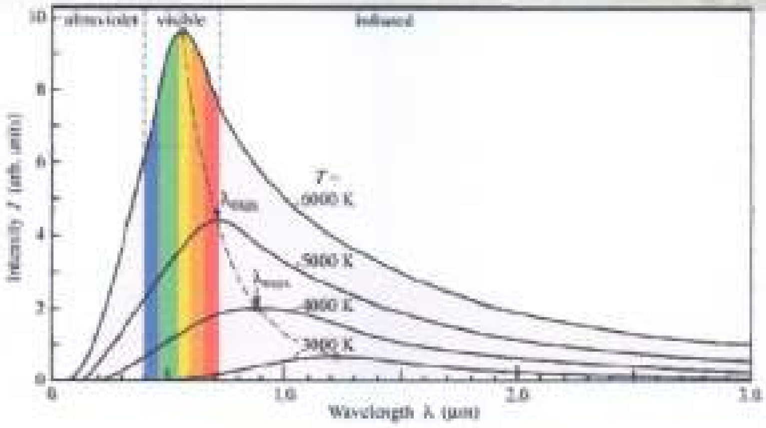
Blackbody = a perfect absorber $a_\lambda = 1$

$$\boxed{e_\lambda = K(\lambda, T)}$$

Energy density emitted by the blackbody is only the function of wavelength and temperature

Blackbody radiation

The Sun's surface is at about 6000 K and this gives λmax=480 nm



Electrical, Computer, & Systems Engineering of Rensselear. *§18: Planckian sources and color temperature* http://www.ecse.rpi.edu (July 27, 2007).

$$\lambda_{\max} T = 2.9 \cdot 10^{-3}\, m \cdot K$$

This result is known as the **Wien displacement law**

Experimental curve difficult to describe theoretically

Historical introduction to quantum mechanics

- It took a long time to find the exact form of $e(\lambda, T)$!

Year	Author	Formulae
1887	Władimir Aleksandrowicz Michelson	$e(\lambda,T) = aT^{3/2}\lambda^{-6}\exp(-b/\lambda^2 T)$
1888	Heinrich Weber	$e(\lambda,T) = a\lambda^{-2}\exp(cT - b/\lambda^2 T^2)$
1896	Wilhelm Wien	$e(\lambda,T) = a\lambda^{-5}\exp(-b/\lambda T)$
1896	Friedrich Paschen	$e(\lambda,T) = a\lambda^{-5,6}\exp(-b/\lambda T)$
1900	Lord Rayleigh	$e(\lambda,T) = aT\lambda^{-4}\exp(-b/\lambda T)$
1900	Otto Lummer i Ernst Pringsheim	$e(\lambda,T) = aT\lambda^{-4}\exp(-b/(\lambda T)^{1.25})$
1900	Otto Lummer i Eugen Jahnke	$e(\lambda,T) = a\lambda^{-5}\exp(-b/(\lambda T)^{0.9})$
1900	Max Thiesen	$e(\lambda,T) = aT^{0.5}\lambda^{-4.5}\exp(-b/\lambda T)$
1900	Max Planck (19 X)	$e(\lambda,T) = a\lambda^{-5}\left(\frac{1}{\exp(b/k\lambda T) - 1}\right)$
1900	Max Planck (14 XII)	$e(\lambda,T) = 8\pi hc\lambda^{-5}\left(\frac{1}{\exp(hc/k\lambda T) - 1}\right)$

Historical introduction to quantum mechanics

Ludwig Boltzmann

(1835-1893)

Mid-1880 Austrian theoretical physicist **Ludwig Boltzmann** using the laws of thermodynamics for an expansion of cylinder with a piston at one end that reflects the blackbody radiation was able to show that the total energy density (integrated over all wavelengths) $u_{tot}(T)$ was given as:

$$\boxed{u_{tot} = \sigma T^4}$$

σ- Stefan-Boltzmann constant $5.68 \cdot 10^{-8}$ W/(m$^2 \cdot$K^4)

By this time Maxwell had formulated his equations. The electromagnetic radiation produces pressure.

Historical introduction to quantum mechanics


(1864-1928)

The next important steps forward were taken a decade later by the German **Wilhelm Wien**, who made two contributions towards finding Kirchhoff's function K(λ,T). One contribution was based on an analogy between the Boltzmann energy distribution for a classical gas consisting of particles in equilibrium and the radiation in the cavity.

The Boltzmann energy distribution describes the relative probability that a molecule in a gas at a temperature T has a given energy E.

This probability is proportional to exp(-E/kT), where k Boltzmann constant $1.38 \cdot 10^{-23}$ J/K, so that higher energies are less likely, and average energy rises with temperature.

Historical introduction to quantum mechanics


(1864-1928)

Wien's analogy suggested that it as also less likely to have radiation of high frequency (small wavelength) and that an exponential involving temperature would play a role. Wien's distribution is given by:

$$\boxed{K_{Wien}(\lambda, T) = b\lambda^{-5}\exp(-a/\lambda T)}$$

a, b are constants to be determined experimentally

In fact, Wien's analogy is not very good. It fits the small-wavelength (or, equivalently, the high-frequency) part of the blackbody spectrum that experiments were beginning to reveal.

It represents the first attempt to „derive" Kirchhoff's function from the classical physics which is **impossible**

Historical introduction to quantum mechanics


(1864-1928)

Second contribution of Wien (more general observation) that on the basis of thermodynamics alone, one can show that Kirchhoff's function, or equivalently, the energy density function u(λ,T), is of the form:

$$\boxed{u(\lambda,T) \propto \lambda^{-5}\varphi(\lambda T)}$$

But this is as far as thermodynamics can go; it cannot determine the function φ.

Historical introduction to quantum mechanics

(1858-1947)

Max Planck was a „reluctant revolutionary”. He never intended to invent the quantum theory, and it took him many years before he began to admit that classical physics was wrong. He was advised against studying physics because *all problems had been solved*!

Planck studied under Kirchhoff at the University of Berlin, and after his death in 1887, Planck succeeded him as a professor of physics there. Planck had a great interest in laws of physics that appeared to be universal. Therefore, he wanted to derive Wien's law from Maxwell's electromagnetic theory and thermodynamics. But this cannot be done!!!

Historical introduction to quantum mechanics

Experimentalists

3.02.1899:

experiments performed up 6 µm, T:800-1400°C indicate deviation from the Wien' distribution

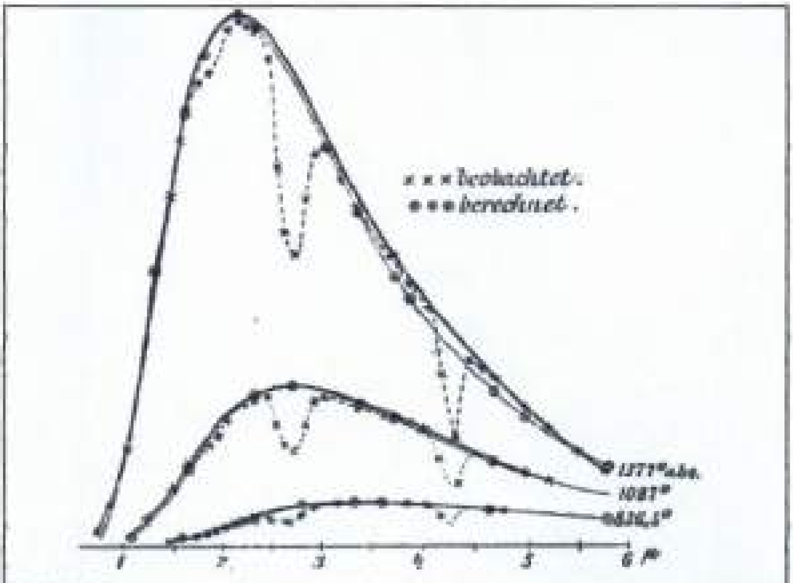


Fig. 24. Energy curves (for page 168) (Lummer and Pringsheim, February 1899, 34: Fig. 1). Thick continuous lines: Experimental data, but continued through the absorption areas indicated by the depressions marked by chain lines, " which [areas] originate partially from water vapour and carbon dioxide in the air ". Thin continuous lines: These join the values *calculated* from the energy distribution equation.

Historical introduction to quantum mechanics

In order to fit the experimental data of Otto Lummer and Ernst Pringsheim and later Heinrich Rubens and Ferdinand Kurlbaum in 1900, Planck proposed a function:

$$\boxed{K(\lambda,T)=\frac{b}{\lambda^5}\frac{1}{\exp(a/\lambda T)-1}}$$

This function fits very well the experimental data at long wavelengths (infrared) where Wien's function failed! At short wavelength limit, when

$$a/\lambda T >> 1$$

we can neglect the 1 in the denominator and recover the Wien law.

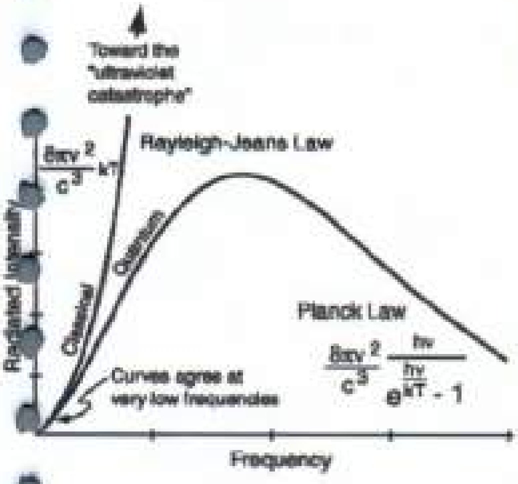
Historical introduction to quantum mechanics


(1858-1947)

Max Planck finally derived the Kirchhoff formula. He introduced a model of a blackbody that contained **„resonators"** which were charges that could oscillate harmonically. He applied statistical physics introduced by Boltzmann but had to make a drastic, quite unjustified assumption (at that time):

Oscillators can only emit or absorb energy of frequency *f* in units of *hf,* where *h* is a new universal constant with dimensions of energy multiplied by time. Planck called these energy units quanta

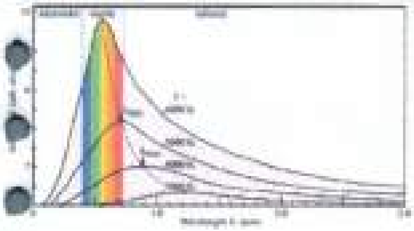
Historical introduction to quantum mechanics



Englishman **John Strutt**, known as **Lord Rayleigh** published a paper on Kirchhoff function only some months earlier than Planck (1900). Rayleigh's idea was to focus on the radiation and not on Planck's material oscillators. He considered this radiation as being made up of standing electromagnetic waves. Energy density of these waves is equivalent to the energy density of a collection of harmonic oscillators. The average energy per oscillator is *kT*

This classical approach, so called Rayleigh-Jeans law, leads to the *„ultraviolet catastrophe"* (integration over all possible frequencies gives infinity for the total energy density of radiation in the cavity)

1.4. Blackbody radiation

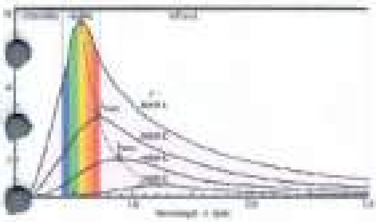


The Rayleigh-Jeans treatment of the energy density showed that the classical ideas lead inevitably to a serious problem in understanding blackbody radiation. However, where classical ideas fail, the idea of radiation as photons with energy *hf* succeeds.

Planck's formula can be derived within the frame of quantum mechanics:

$$u(f,T)=\frac{8\pi hf^{3}}{c^{3}}\frac{1}{\exp(hf/kT)-1}$$

1.4. Blackbody radiation



The **total energy density** (the energy density integrated over all frequencies) for the blackbody radiation is a function of the temperature alone:

$$U(T)=\int_0^\infty u(f,T)df=\int_0^\infty \frac{8\pi hf^3}{c^3}\frac{1}{\exp(hf/kT)-1}df$$

This result of integration gives the Stefan-Boltzmann law, known earlier

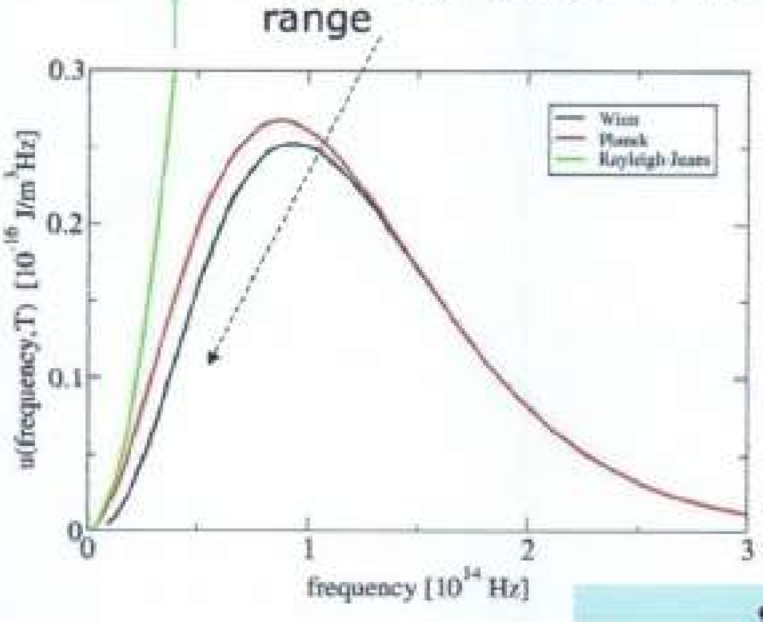
$$U(T)=(7.52\cdot10^{-16}J/m^3\cdot K^4)T^4$$

It was not possible to calculate the constant multiplying the T^4 factor until Planck's work, because this constant depends on *h*.

Historical models of blackbody radiation

Rayleigh-Jeans law leads to the *„ultraviolet catastrophe"*

Wien equation does not fit well low frequency range



Planck's formula is true

$$u(f,T)=\frac{8\pi hf^3}{c^3}\frac{1}{\exp(hf/kT)-1}$$

Blackbody radiation

Albert Einstein

(1879-1955)

In 1905, **Albert Einstein** was sure that it was impossible to derive Planck's formula – which he took as correct – from classical physics. Correctness of the full Planck formula means the end of classical physics.

Limits of Planck's formula:

$$u(f,T)=\frac{8\pi hf^3}{c^3}\frac{1}{\exp(hf/kT)-1}$$

High frequency limit: $hf/kT \gg 1$

$$u(f,T)=\frac{8\pi hf^3}{c^3}\exp(-hf/kT)$$ Wien's result

Low frequency limit: $hf/kT \ll 1$

This can happen if *f* is small or *T* is large, or if we imagine a world in which *h* tends to zero (the classical world)

Limits of Planck's formula:

For small *x*: $$\exp(x) \approx 1 + x$$

Then:

$$u(f,T) \approx \frac{8\pi h f^3}{c^3} \frac{1}{1 + (hf/kT) - 1} = \frac{8\pi f^2 kT}{c^3}$$

This is exactly the Rayleigh's classical answer

Einstein's contribution


(1879-1955)

Extremely radical proposal of energy quantization:

- at the Rayleigh-Jeans, or low-frequency, end of the spectrum, the usual Maxwell description in terms of waves works
- at the Wien, or high-frequency, end of the spectrum, radiation can be thought of as a „gas" of quanta

Radiation sometimes acts like particles and sometimes like waves.

energy of particle → $E = hf$ ← frequency of wave

AGH

„Particle" nature of radiation

Experimental confirmation :

- photoelectric effect (liberation of electrons from the metallic surface by illumination of certain frequency)
- Compton effect (scattering of X-rays with a change of frequency)

These effects, similarly to the blackbody radiation, could not be explained by the wave-like character of electromagnetic radiation

Conclusions

- From the mid-19th through the early 20th century, scientists studied new and puzzling phenomena concerning the nature of matter and energy in all its forms
- The most remarkable success stories in all of science resulted from that (and Nobel prizes)
- History of quantum mechanics, which began in mystery and confusion, at the end of century has come to dominate the economies of modern nations

Ramachandra Patra
14.3.19

Department of Physics, Pattamundai College.

Students Attendance on the seminar

"**Historical Introduction to quantum Mechanics**" on dt. 14.03 2019

Sl.No.	Roll No.	Signature of the Student
1	BS17 138	Khirod Ku. Sethi
2	BS17079	sandeep Kumar Behera
3	BS-17-133	Niranjan Das
4	BS-17-007	Nousad Khan
5	BS-17 146	Janmejay Pradhan,
6	BS-18050	Suvam Lenka
7	BS-16-006	Arajit Bagal.
8	BS-16-117	Sushanta Ku. Bal
9	BS-18-034	Kalipada Giri
10	BS-16 -144	Anand Ku Rout
11	BS16 - 026	Debasis Panda
12	BS16-034	Dipak Das
13	BS-16 - 139	Sri Shiv Behera
14	BS-18-102	Bebeki Behera
15	BS- 17- 064	Srinibash Sahu
16	BS-18-072	Pradeep Kumar Dash,
17	BS-18-084	Sonal Nayak
18	BS-17-109	Adit Kumar Gahan
19	BS-17 - 113	Surya Kanta Dash
20	BS16 -041	Subhranshu Ku. Behera
21	BS-18-052	Madhusudan Behera
22	BS- 18 - 109	Bibhudatta Panda.
23	BS-17 - 155	Biswaranjan Sahoo
24	BS 18-055	Sarojini Jena
25	BS 18 132	Barsharani Sahoo
26	BS18100	A. Smruti Snigdha Behera
27	BS18 131	Bhagyashree Mohanty
28	BS18115	Puja Satapathy
29	BS18132	Aparna Moharana
30	BS 18176	Dipika Rani Dash
31	BS17-150	Silpa rani Das

32	BS-17-128	Sukalyani Behera.
33	BS-17-114	Archana Mallick
34	BS-17-129	Bijayalaxmi Sarangi
35	BS-17-117	Deepali Sahoo
36	BS-17-044	Subhasmita Rout
37	BS-17-032	Laxmipriya Sahoo
38	BS-17-136.	Jajnyasenee Das
39	BS-17-120	Nibedita Patra
40	BS-16-134	Sonu Patra
11	BS-16-106	Arpita Priyadarshani Rout
42	BS16-001	Swatiprava Sahoo
43	BS 16-147	Tanushree parida
44	BS16-014	Debasmita Bhuyan
45	BS16-256	Sasmita Sahoo
46	Bs-16-146	Priyanka Kund
47	BS16-129	Swapnarani Panda
48	BS16-130	Monalica Nash
49	BS 16-045	Satyabati Sahoo
50	BS 16-123	Manisha Parida
51	BS16-004	Shuvasini Sahoo
52	BS-16-102	Rasmita Swain
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A SEMINAR

ON

"THERMO COUPLE ELECTRICITY"

Presented by:

Mr. Ranjeet Kumar Das
Lecturer in Physics Kendrapara
Autonomous College, Kendrapara.

On

4th Dec 2017

DEPARTMENT OF PHYSICS
PATTAMUDAI COLLEGE,
PATTAMUNDAI.

REPORT

A seminar was organised by Department of Physics, Pattamundai College, pattamundai on 04.12.2017 on the topic "THERMO COUPLE ELECTRICITY". Mr. Ranjeet Kumar Das, Lecturer in Physics Kendrapara Autonomous College, Kendrapara was the resource person for the seminar. In this seminar Mr. Ramesh Chandra sahoo, principal, chaired the meeting. Dr Ramesh Kumar Sahoo, Head of the Department gave a key note address of the topic and welcomed the guests on the dais as well as participant. The meeting was ended with vote of thanks by Mr. Baikunth Charan Roul, another faculty member.

****

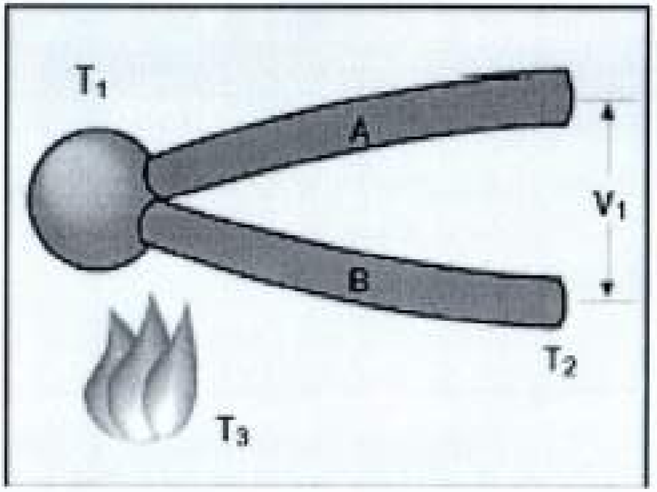
Thermocouples
Electricity

By

Ranjeet Kumar Das,Lecturer in Physics
Kendrapara,
Autonomous College, Kendrapara

What are thermocouples?

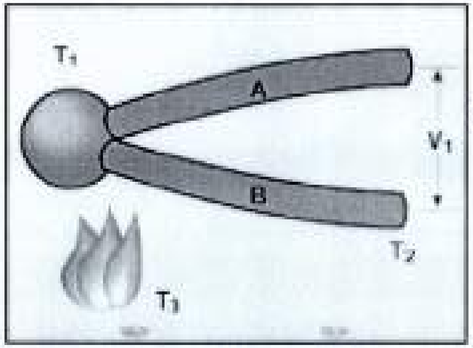
- Thermocouples operate under the principle that a circuit made by connecting two dissimilar metals produces a measurable voltage (emf-electromotive force) when a temperature gradient is imposed between one end and the other.



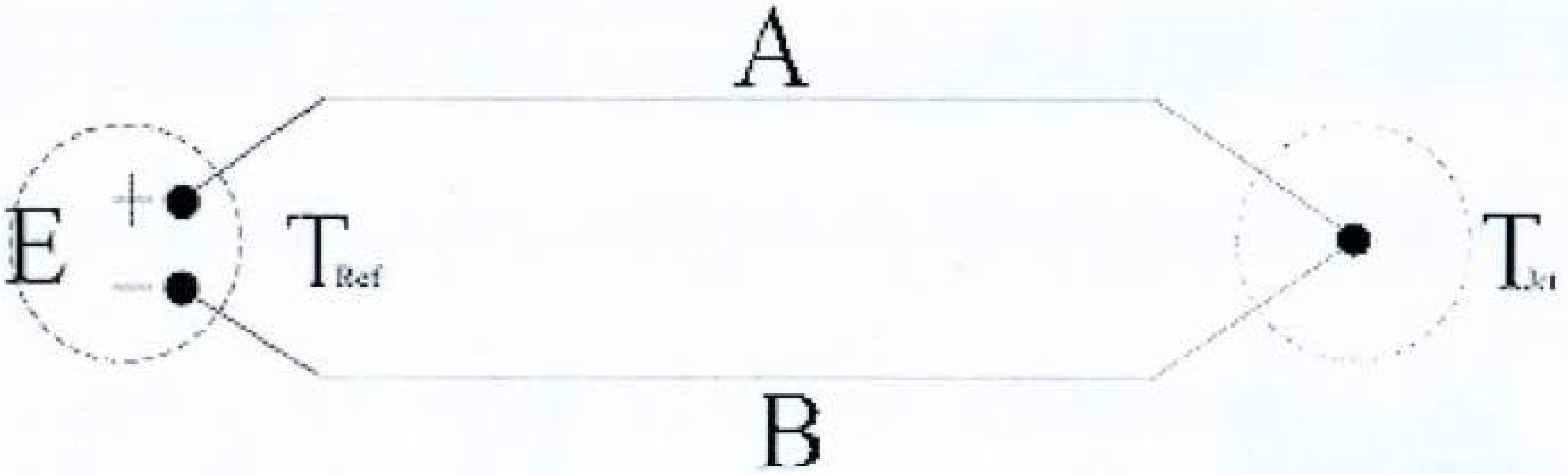
- They are inexpensive, small, rugged and accurate when used with an understanding of their peculiarities.

Thermocouples Principle of Operation

- In, 1821 T. J. Seebeck observed the existence of an electromotive force (EMF) at the junction formed between two dissimilar metals (Seebeck effect).
    - Seebeck effect is actually the combined result of two other phenomena, Thomson and Peltier effects.
        - Thomson observed the existence of an EMF due to the contact of two dissimilar metals at the junction temperature.
        - Peltier discovered that temperature gradients along conductors in a circuit generate an EMF.
        - The Thomson effect is normally much smaller than the Peltier effect.

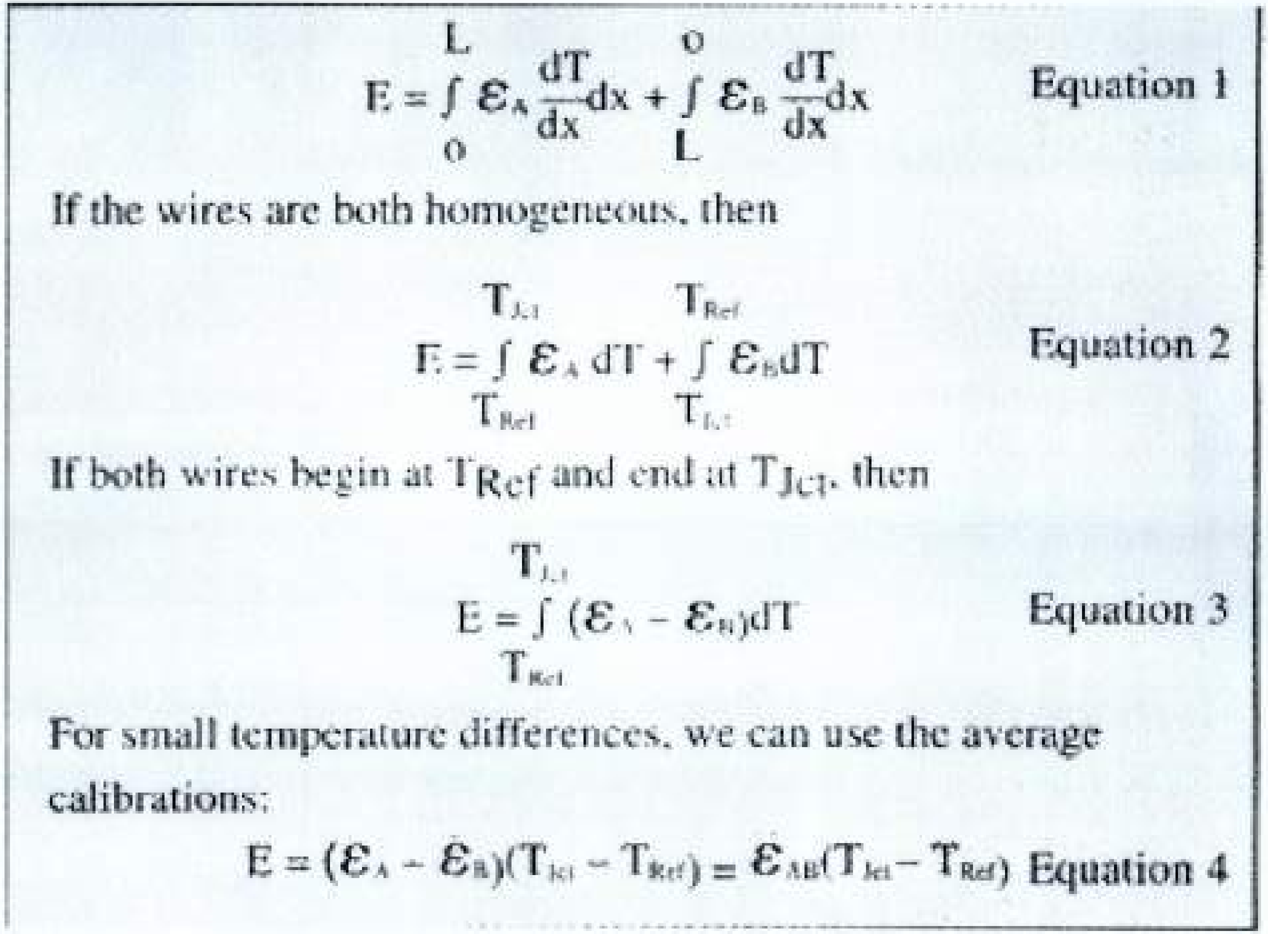


Let's take a look at this circuit



How thermocouples work

- It is generally reasonable to assume that the emf is generated in the wires, not in the junction. The signal is generated when dT/dx is not zero.
- When the materials are homogeneous, ε, the thermoelectric power, is a function of temperature only.
- Two wires begin and end at the same two temperatures.



$$E = \int_{0}^{L} \mathcal{E}_A \frac{dT}{dx} dx + \int_{L}^{0} \mathcal{E}_B \frac{dT}{dx} dx \qquad \text{Equation 1}$$

If the wires are both homogeneous, then

$$E = \int_{T_{Ref}}^{T_{JCT}} \mathcal{E}_A \, dT + \int_{T_{JCT}}^{T_{Ref}} \mathcal{E}_B \, dT \qquad \text{Equation 2}$$

If both wires begin at T_{Ref} and end at T_{JCT}, then

$$E = \int_{T_{Ref}}^{T_{JCT}} (\mathcal{E}_A - \mathcal{E}_B) dT \qquad \text{Equation 3}$$

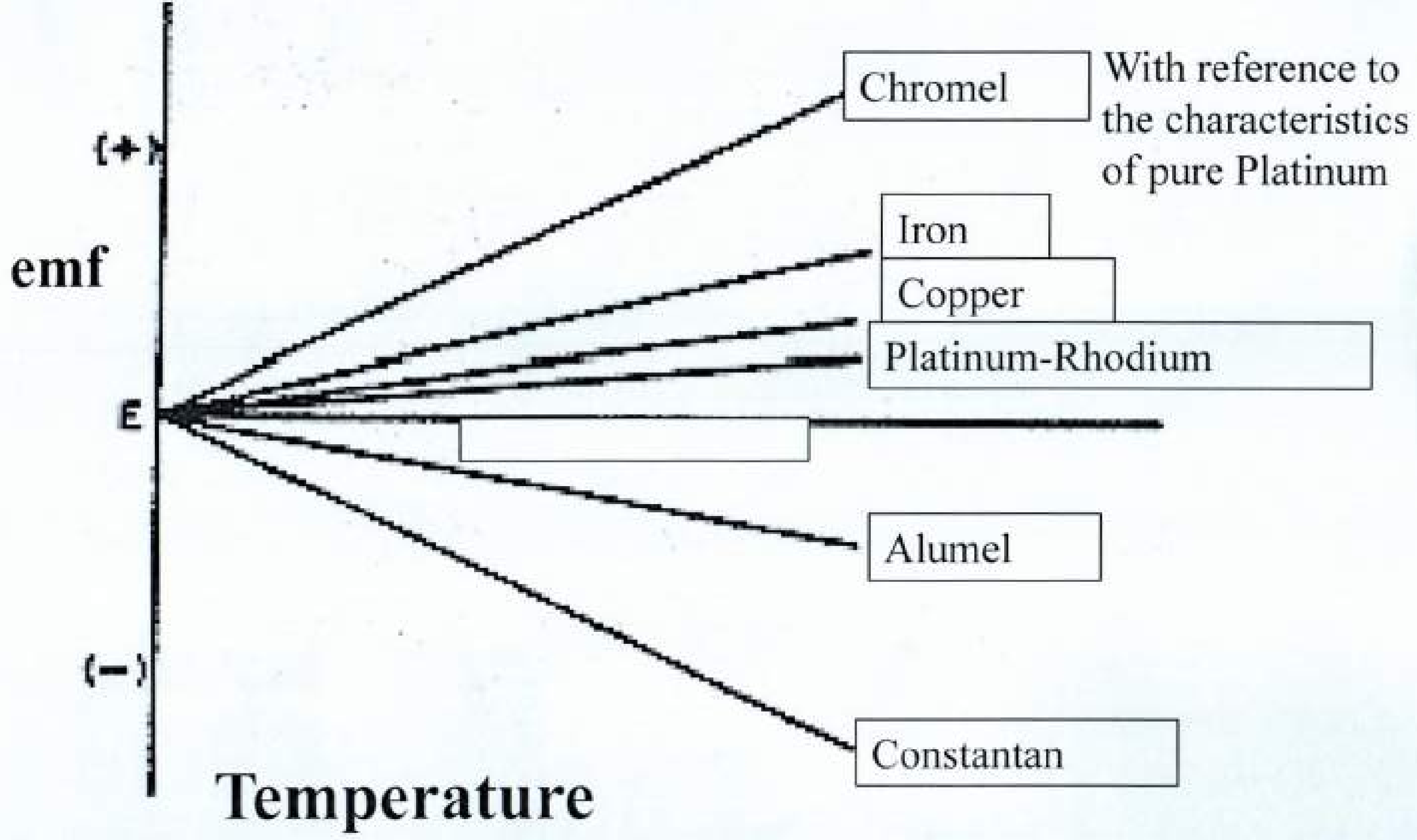
For small temperature differences, we can use the average calibrations:

$$E = (\mathcal{E}_A - \mathcal{E}_B)(T_{Jct} - T_{Ref}) = \mathcal{E}_{AB}(T_{Jct} - T_{Ref}) \qquad \text{Equation 4}$$

Generally, a second order Eqn. is used.

$$E = \alpha(T - T_o) + \beta(T - T_o)^2$$

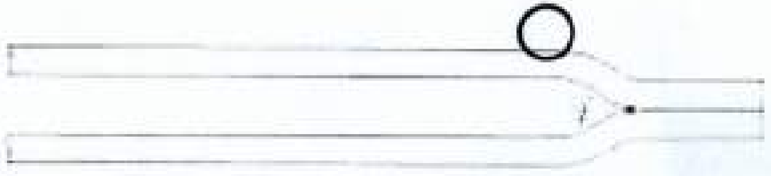
Material EMF versus Temperature



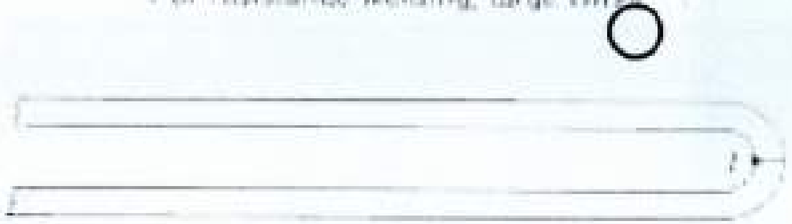
Thermocouple Effect

- Any time a pair of dissimilar wires is joined to make a circuit and a thermal gradient is imposed, an emf voltage will be generated.
  - Twisted, soldered or welded junctions are acceptable. Welding is most common.
  - Keep weld bead or solder bead diameter within 10-15% of wire diameter
  - Welding is generally quicker than soldering but both are equally acceptable
  - Voltage or EMF produced depends on:
    - Types of materials used
    - Temperature difference between the measuring junction and the reference junction

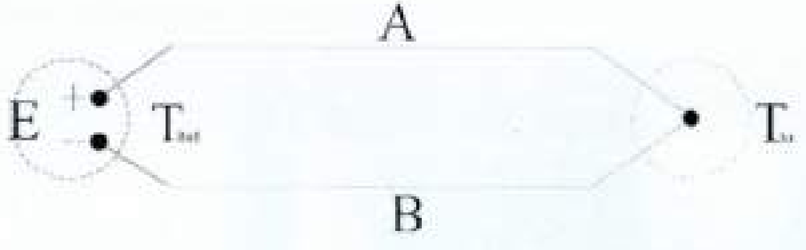
For gas, electric, and arc welding



For resistance welding, large wires



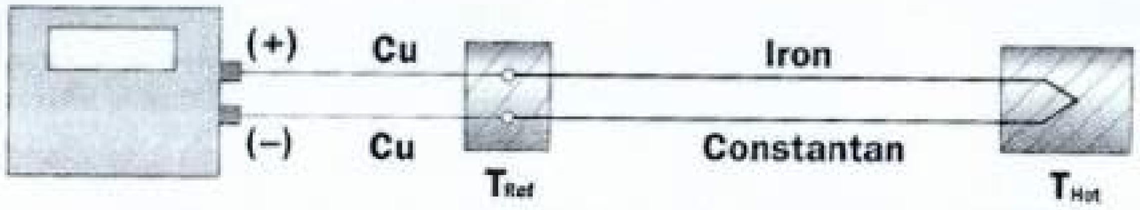
For forming noble metal wires for electric arc welding



Thermocouple Tables (EMF-Temperature)

- Thermocouple tables correlate temperature to emf voltage.
  - Need to keep in mind that the thermocouple tables provide a voltage value with respect to a reference temperature. Usually the reference temperature is 0°C. If your reference junction is not at 0°C, a correction must be applied using the law of intermediate temperatures.

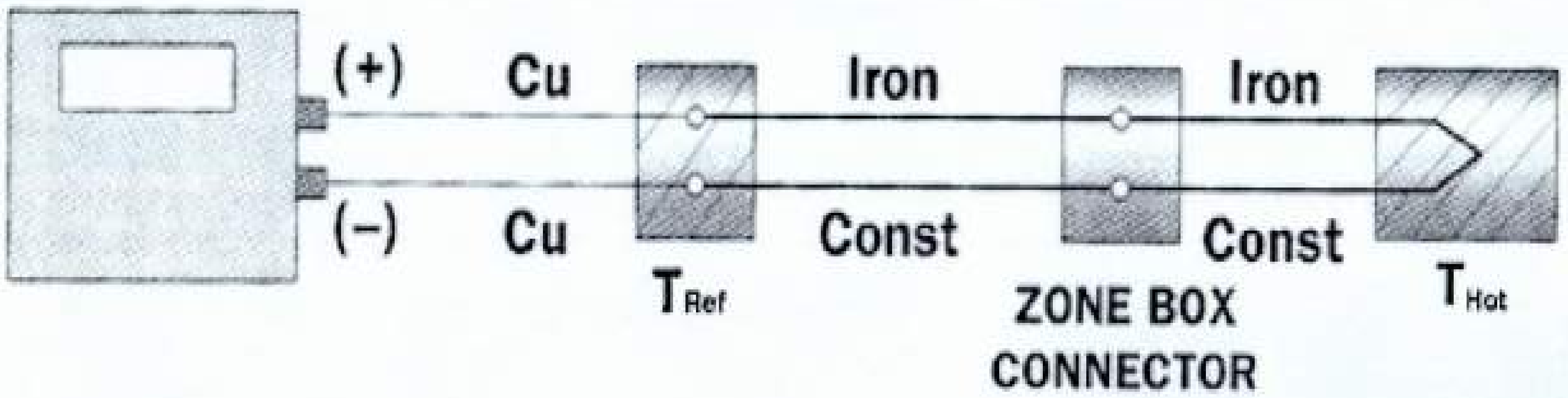
Reference Temperature Systems and Zone Boxes



- Ice Baths
  - Accurate and inexpensive
- Electronically Controlled References
  - Require periodic calibration and are generally not as stable as ice baths, but are more convenient.

Zone boxes

– A zone of uniform temperature
that insures all connections made
within the zone are at the same temperature.

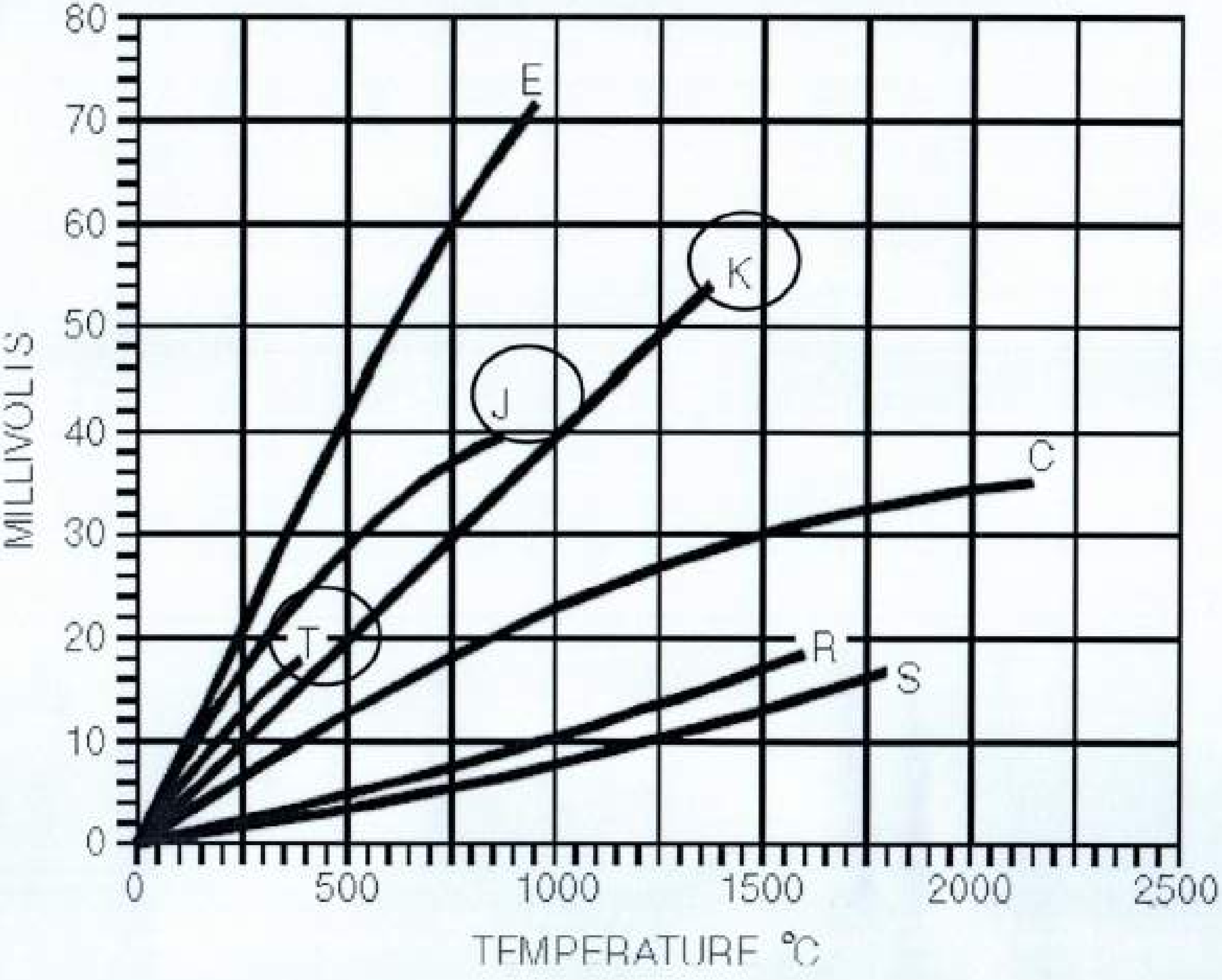


What thermocouple materials should be used?

- Depends on requirements:
  - Temperature range?
  - Required accuracy
  - Chemical resistance issues
  - Abrasion or vibration resistance
  - Installation requirements (size of wire)
  - Thermal conduction requirements

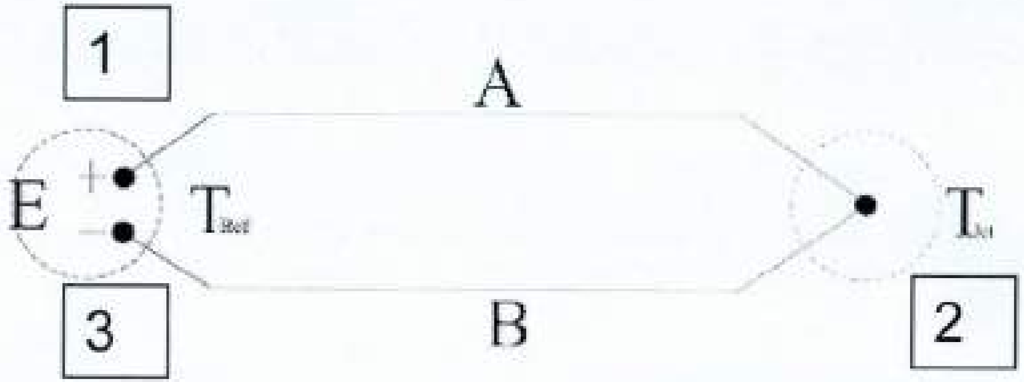
Thermocouple Material Vs EMF

Types T, J, and K are most commonly used thermocouples (see Table 16.8 of the "Handbook").

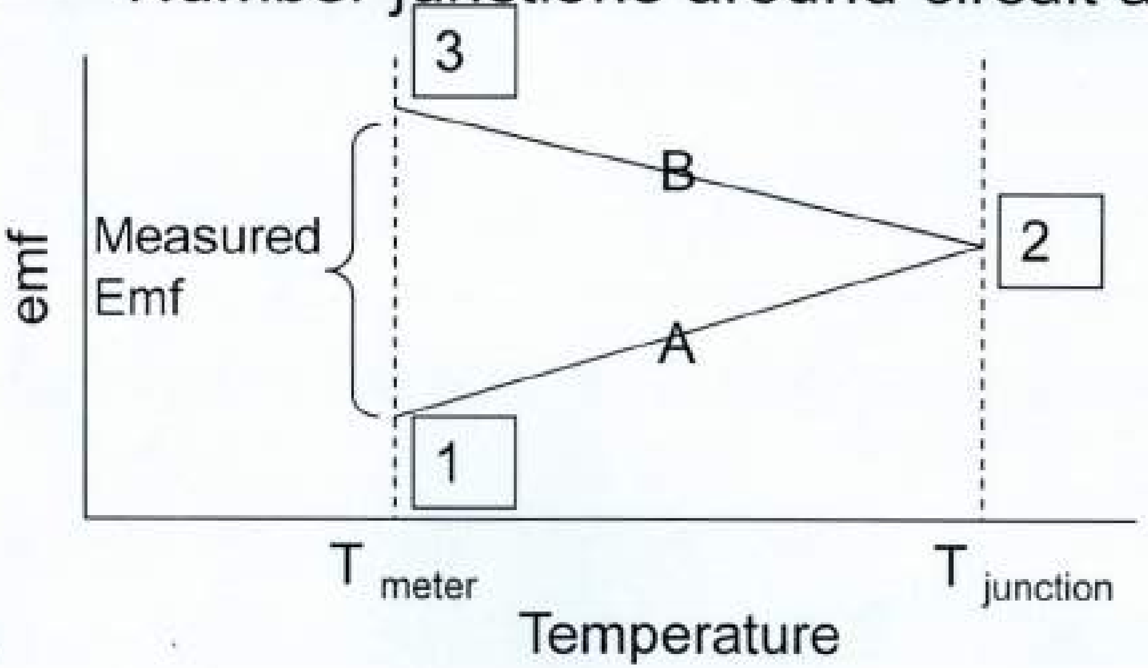


Simple TC Model "EMF-Temperature Sketch"

- Two materials
  - Material A (+)
  - Material B (-)
    - Plus and minus refers to how the emf changes with temperature.



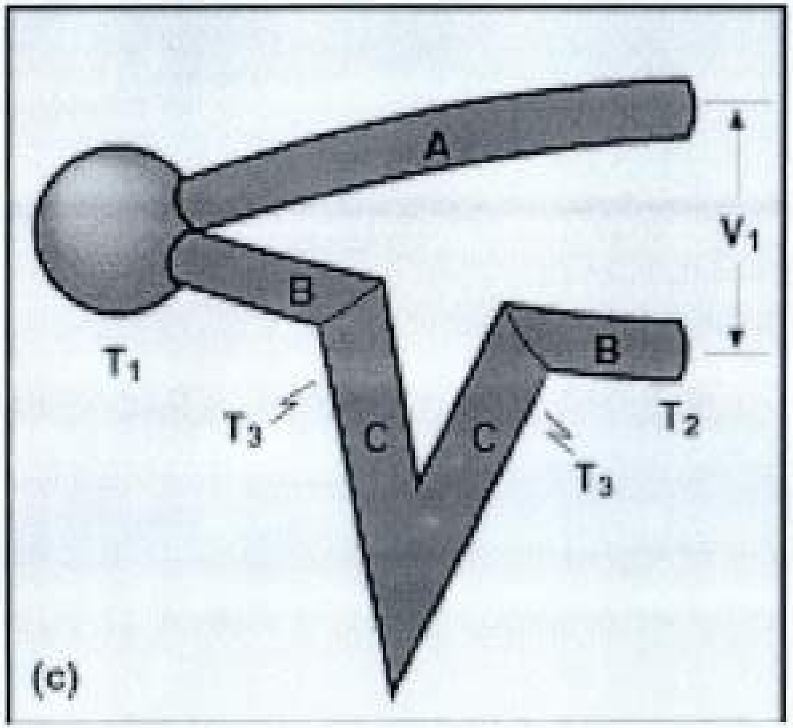
Number junctions around circuit and draw

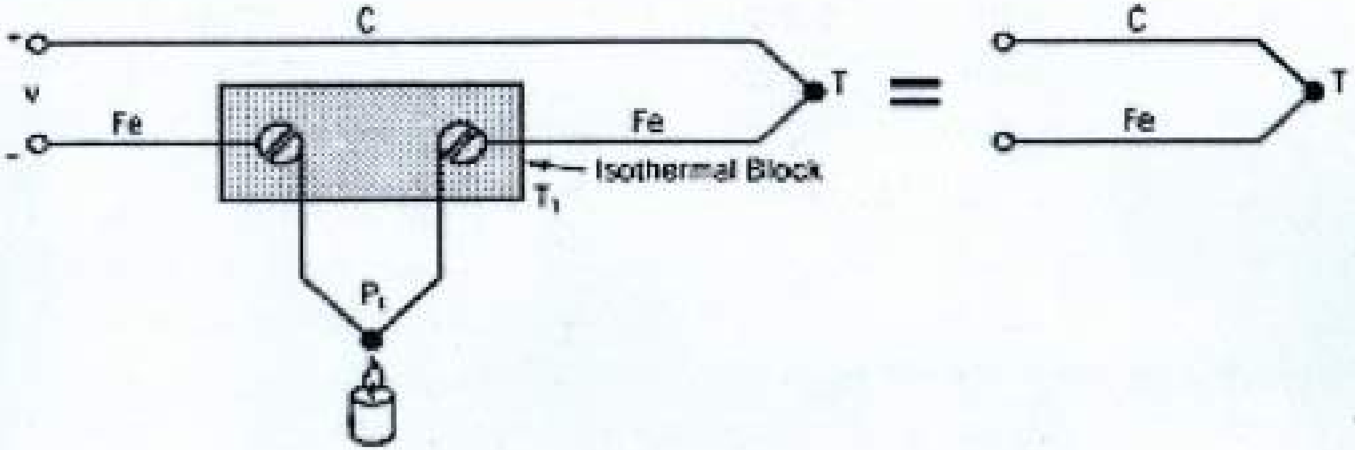


Law of Intermediate Metals

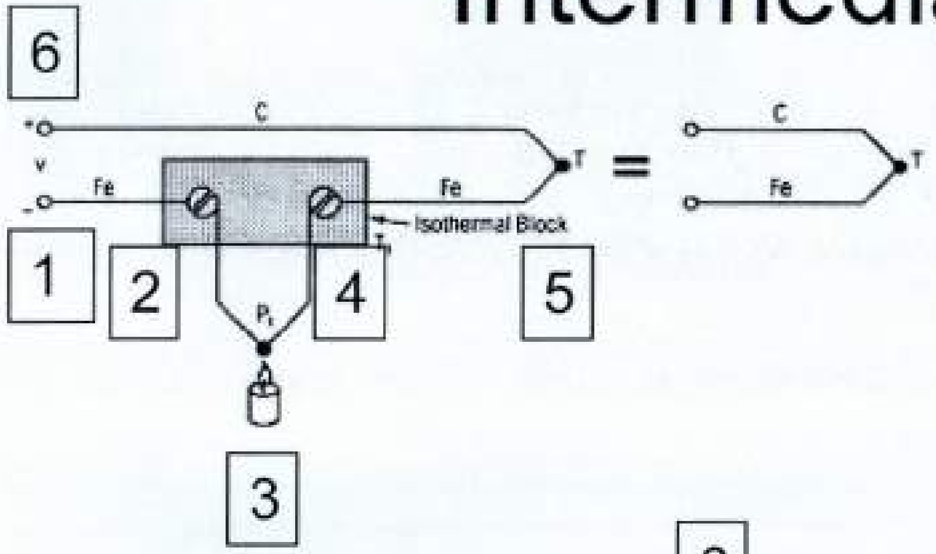
2) Insertion of an intermediate metal into a thermocouple circuit will not affect the emf voltage output so long as the two junctions are at the same temperature and the material is homogeneous.

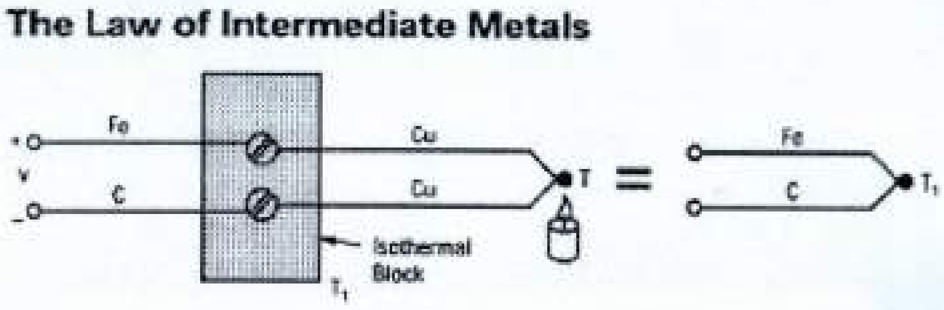
- Permits soldered and welded joints.

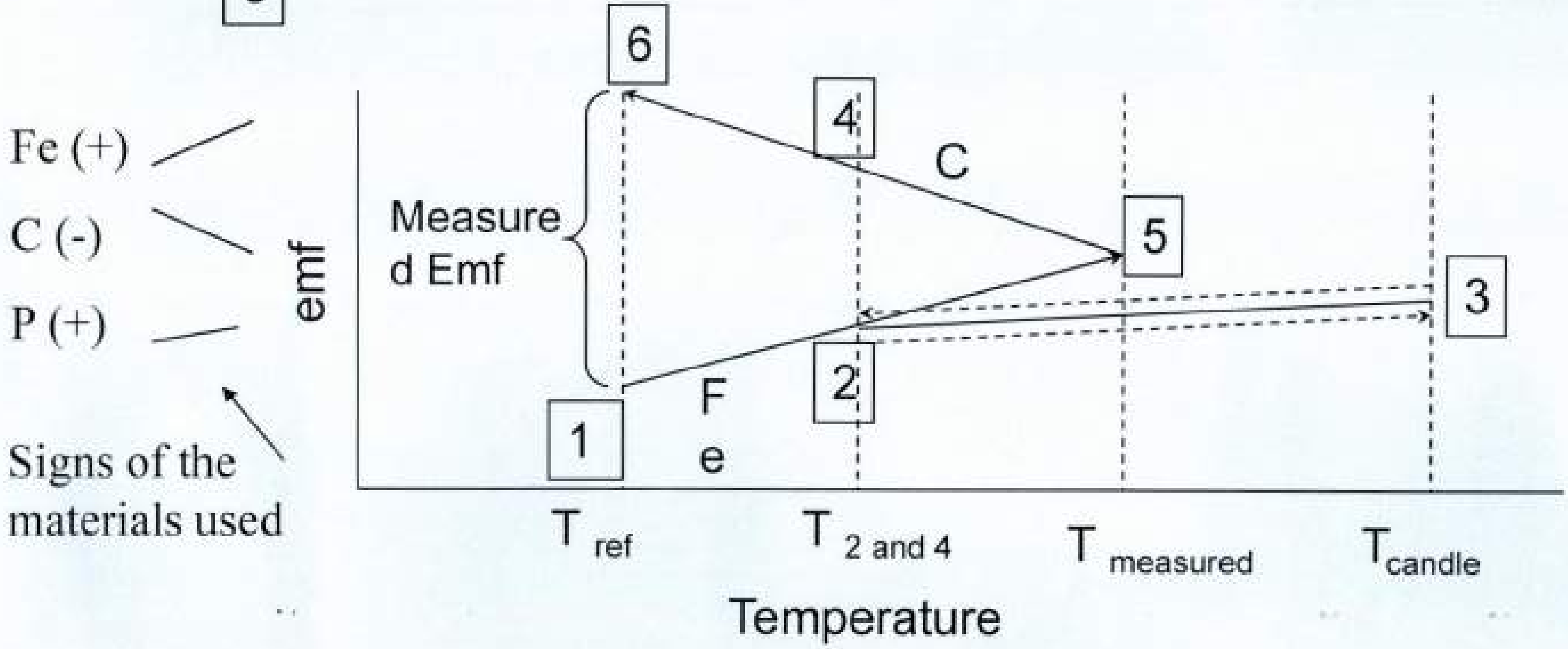




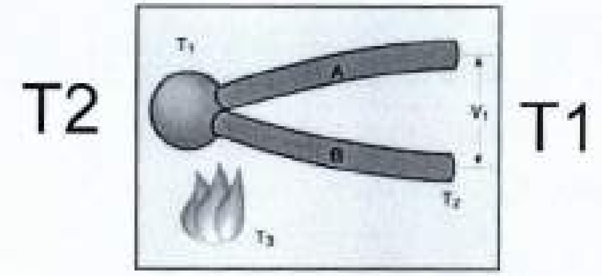
A Demonstration of the Law of Intermediate Metals

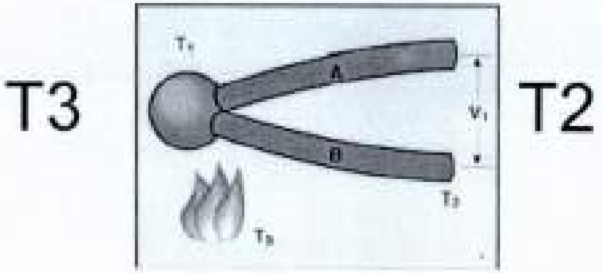


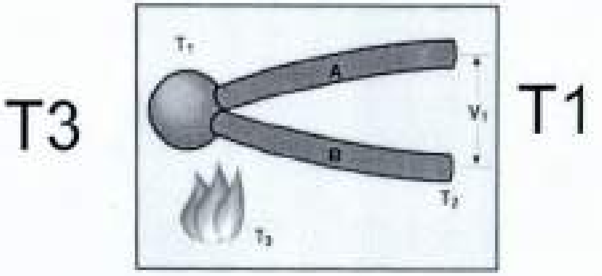




Law of Intermediate Temperatures





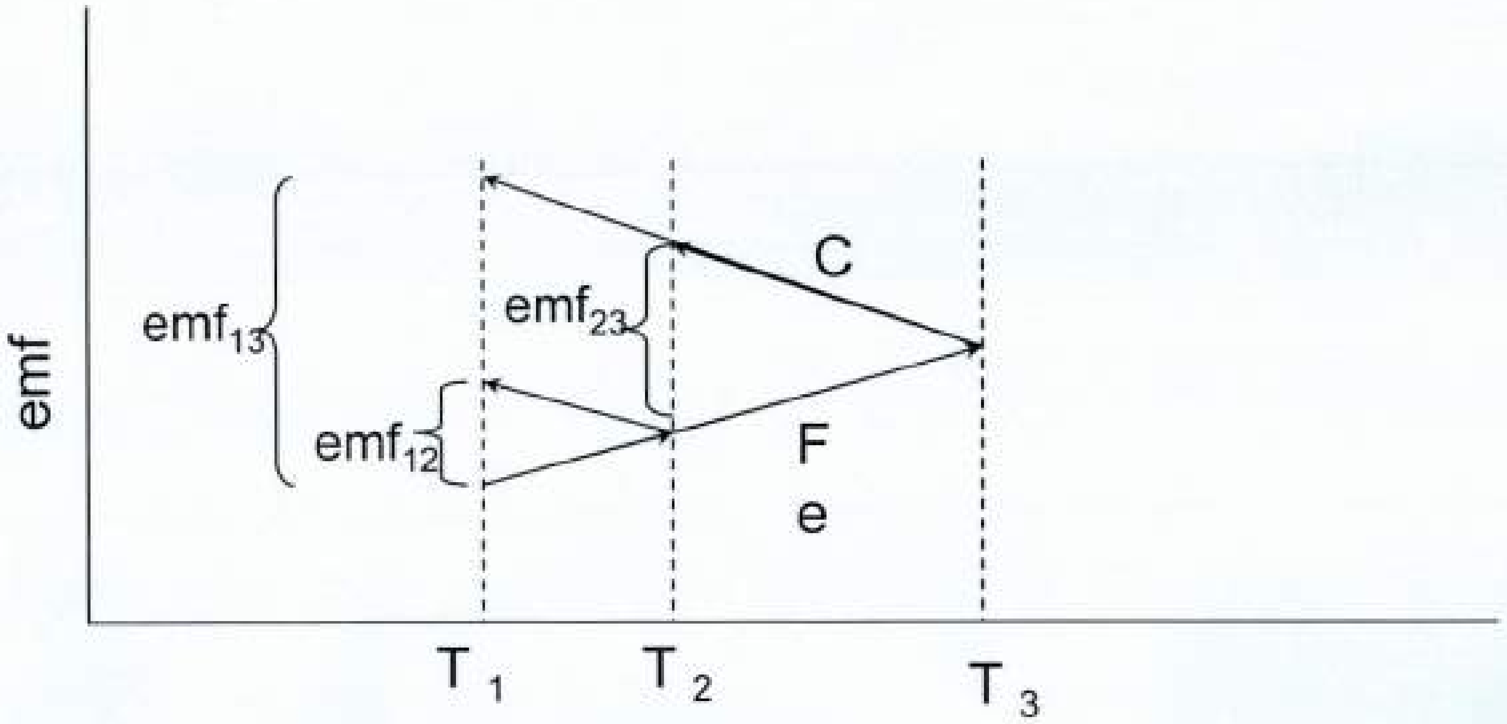


If a thermocouple circuit develops a net emf_{1-2} for measuring junction temperatures T_1 and T_2, and a net emf_{2-3} for temperatures T_2 and T_3, then it will develop a net voltage of $emf_{1-3} = emf_{1-2} + emf_{2-3}$ when the junctions are at temperatures T_1 and T_3.

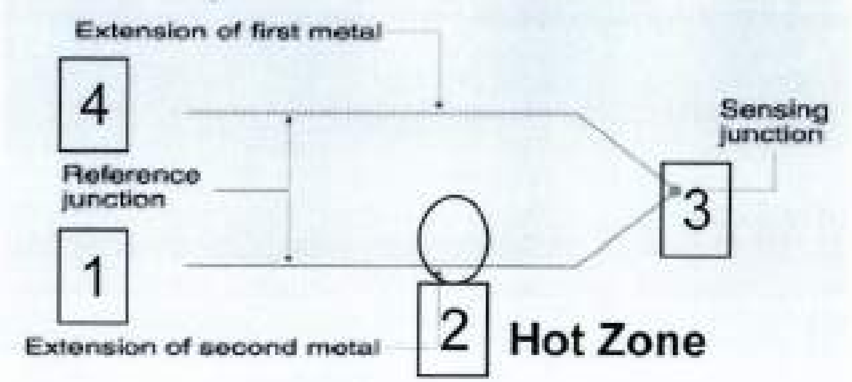
$$\mathbf{emf_{1-2} + emf_{2-3} = emf_{1-3}}$$

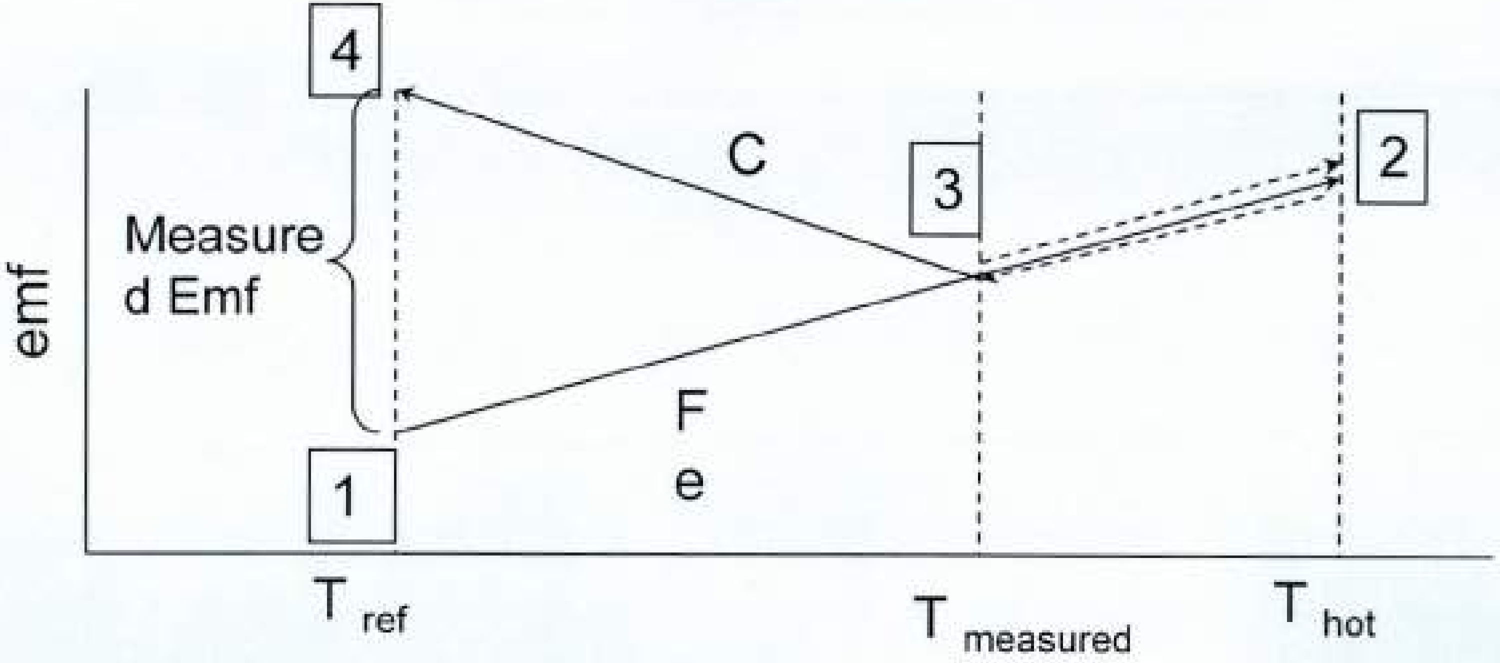
A Demonstration of the Law of Intermediate Temperatures

$$\mathrm{emf}_{1\text{-}2} + \mathrm{emf}_{2\text{-}3} = \mathrm{emf}_{1\text{-}3}$$



A Demonstration of the Law of Intermediate Temperatures





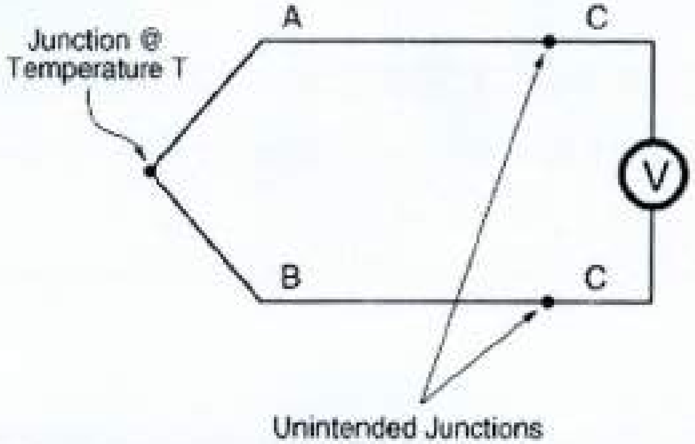
If a thermocouple circuit of materials A and C generates a net $\text{emf}_{A\text{-}C}$ when exposed to temperatures T_1 and T_2, and a thermocouple of materials C and B generates a net $\text{emf}_{C\text{-}B}$ for the same two temperatures T_1 and T_2, then a thermocouple made from materials A and B will develop a net voltage of

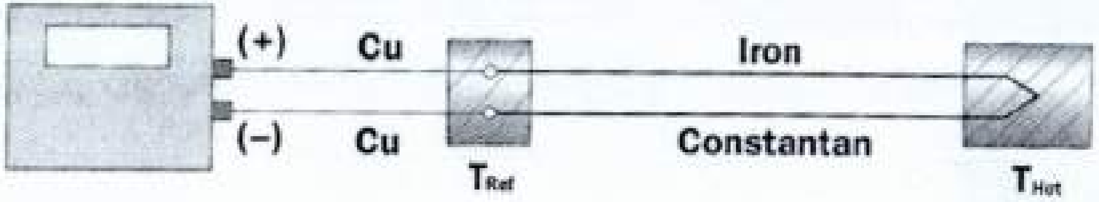
$$\text{emf}_{A\text{-}B} = \text{emf}_{A\text{-}C} + \text{emf}_{C\text{-}B}$$

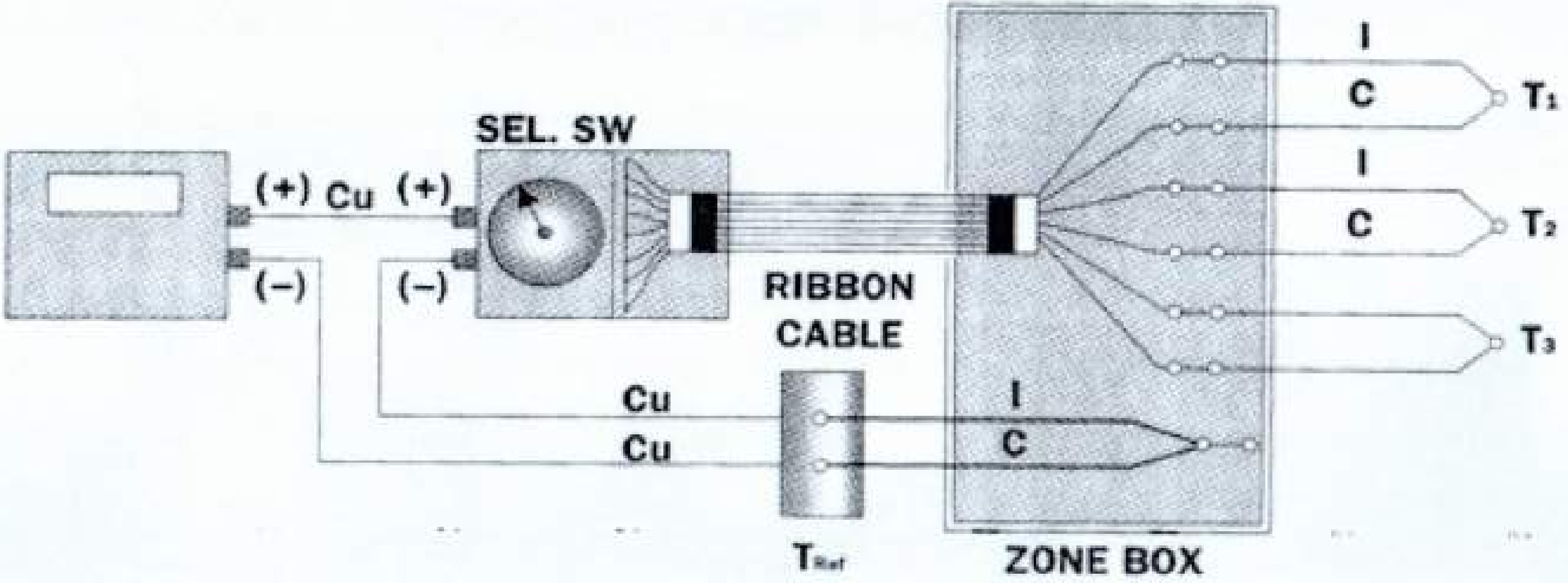
between temperatures T_1 and T_2.

- Sometimes useful in the calibration of different thermocouple wires.

Single and multiplexing







Temperature Measurement Errors

- Conduction
- Convection
- Radiation
- Response Time
- Noise
- Grounding issues and shorts, especially on metal surfaces

Ranjeet Kumar Das

Department of Physics, Pattamundai College.

Students Attendance on the seminar

"Thermo Couple Electricity" on Dt. 04.12.2017

Sl.No.	Roll No.	Signature of the Student
1	BS17-120	Nibedita Patra.
2	BS17-128	Sukanti Rani Behera.
3	BS17-129	Bijayalaxmi Sarangi
4	BS17-132	Laxmipriya Sahoo
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PATTAMUNDAI COLLEGE, PATTAMUNDAI
SEMINAR ON :
THERMO COUPLE ELECTRICITY
Organised by :
Department of Physics
4th DECEMBER 2017
Resource Person :RANJEET KUMAR DAS
Kendrapara Auto College, Kendrapara


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MI DUAL CAMERA

A SEMINAR

ON

"ULTRA VIOLET CATASTROPHE"

Presented by:

Mr.Rama Chandra Patra
Reader in Physics Kendrapara
Autonomous College, Kendrapara.

On

11th Dec 2017

DEPARTMENT OF PHYSICS
PATTAMUDAI COLLEGE,
PATTAMUNDAI.

REPORT

A seminar was organised by Department of Physics, Pattamundai College, pattamundai on 11.12.2017 on the topic "ULTRA VIOLET CATASTROPHE". Mr. Rama Chandar Patra, Reader in Physics, Kendrapara Autonomous College, Kendrapara, was the resource person for the seminar. Dr Promd Kumar Samal, Head of the Department History chaired the meeting. Dr Ramesh Kumar Sahoo, Head of the Department, welcomed the guests on the dais and the participants and also gave a key note address of the topic. The meeting was ended with vote of thanks by Mr. Baikunth Charan Roul, another faculty member.

****

Ultraviolet catastrophe

by

Rama Chandra Patra,

Reader in Physics, kendrapara Auto college, kendrapara

Thermal radiation

What is thermal radiation?

Thermal radiation is the electromagnetic radiation emitted by a body as a result of its temperature.

- All bodies emit such radiation to their surroundings and absorb such radiation from them.
- Usually, most of the radiation is emitted in frequencies outside the visible range. (for example, at the infrared at room temperature)
- All bodies (solids and liquids) emit a continuous spectrum of radiation.
  - Practically independent of composition
  - Strongly dependent on the temperature.

Backbody radiation: experimental results

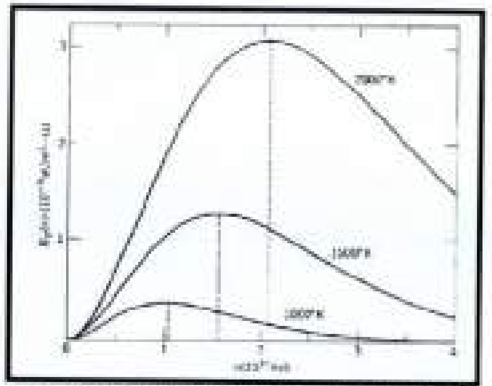


Figure 2. First accurate measurements of $R_T(\nu)$ by Lummer and Pringsheim (1899)

How do we measure the blackbody spectrum?

We define the **spectral radiancy** $R_T(\nu)$ such as $R_T(\nu)\,d\nu$ is the energy emitted per unit time in the frequency interval $[\nu, \nu + d\nu]$ from a unit area of the surface at temperature T.

Total Radiancy

The total energy emitted per unit time per unit area is called the **Radiancy** R_T

$$R_T = \int_0^\infty R_T(\nu)\,d\nu$$

Blackbody Radiation

- When radiation impinges on a body, partly is absorbed and partly is reflected
- A black body is the one that **absorbs all the radiation coming on it**
- Independently of their composition, all blackbodies at the same temperature emit thermal radiation <u>with the same spectrum</u>.
- Examples of black bodies:
  - Body painted in black (reflecting very little light)
  - Cavity connected by a small hole to the outside

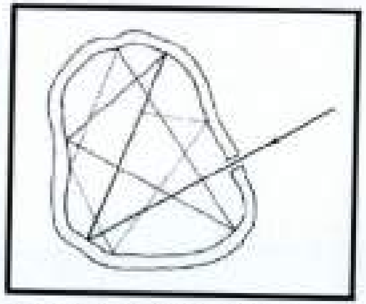


Figure 1. Incident radiation is completely adsorbed after succesive reflections. The radiation emitted by the hole will have a blackbody spectrum

Stefan's and Wien's laws

Stefan's law for the total radiancy (1879)

Figure 2 shows that the total radiancy emitted by a black body increases very rapidly with temperature. It 1879 the following empirical equation was found:

$$R_T = \sigma T^4 \qquad (1)$$

where $\sigma = 5,67 \cdot 10^{-8} W/m^2K^4$ is called the **Stefan-Boltzmann constant**.

Wien's displacement law (1893)

Figure 2 also shows that the maximum of the spectrum shifts to larger frequencies as T increases, in a linear fashion. This fact is called the Wien's displacement law, first stated in 1893:

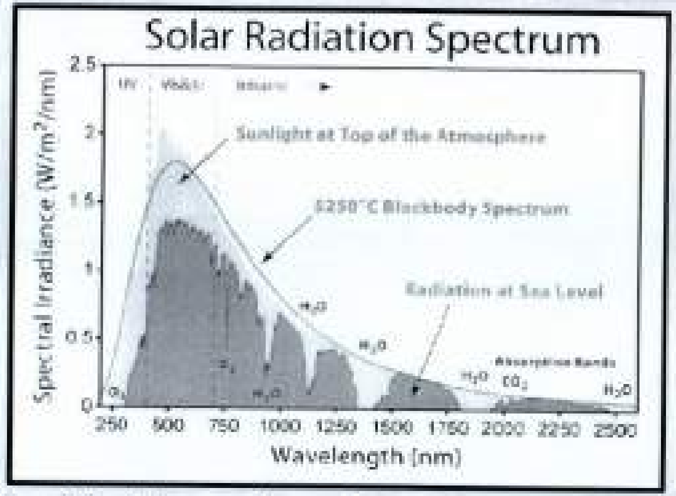
$$\nu_{max} \propto T \qquad (2)$$

Then, not only the amount of thermal radiation will increase with temperature, but also the color of a glowing hot body will change, from red to blue-white.
Wien's law can also be put in the form:

$$\lambda_{max} T = 2,898 \cdot 10^{-3} mK \qquad (3)$$

Stars as black bodies

Does the sun behave like a black body?



Conclusion: Wien's law can be used to estimate temperature of stars

Classical theory of cavity radiation

We will now take as a blackbody example the cavity shown in Figure 1 and calculate, using classical physics, the energy density $\rho_T(\nu)$ inside. This quantity is defined as the energy contained in a unit volume of the cavity at temperature T in the frequency interval ν to $\nu + d\nu$, and is related to the spectral radiancy by the relationship

$$R_T(\nu) = \frac{c}{4}\rho_T(\nu) \qquad (4)$$

Light waves

Let's remember that light is classicaly assumed to be electromagnetic waves that propagate in vacuum according to the wave equation for their electric and magnetic components:

$$\frac{\partial^2 E(x,t)}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 E(x,t)}{\partial t^2} = 0 \qquad \frac{\partial^2 B(x,t)}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 B(x,t)}{\partial t^2} = 0 \quad (5)$$

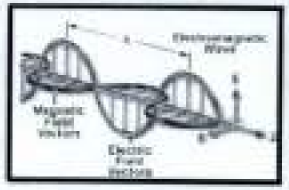
being c the speed of propagation of light ($3 \cdot 10^8$ m/s in vacuum).

Classical theory of cavity radiation

Harmonic waves

The most simple example of an electromagnetic wave is the harmonic or sinusoidal wave. For propagation along the *z* direction, the solution of the wave equation takes the form:

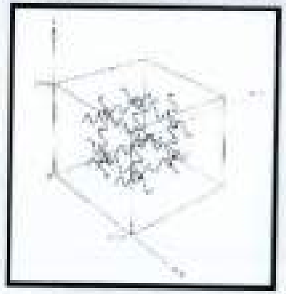
$$\hat{E}(z,t) = E_i \sin(kz - \omega t)\hat{i} \qquad \hat{B}(z,t) = B_j \sin(kz - \omega t)\hat{j} \qquad (6)$$



k: wave number ω: angular frequency
begin the frequency ν defined as
$\nu = \omega/2\pi = 1/T$ (T = period)
and the wavelenght λ defined as $\lambda = 2\pi/k$
The velocity of propagation *c* is then
$c = \omega/k = \lambda\nu$
which in vacuum is independent of *k*

Classical theory of cavity radiation

Rayleigh-Jeans calculations



- For simplicity, we assume a metallic cubic cavity filled with electromagnetic radiation. The incident and reflected waves combine to form standing waves.
- As the electric field vector $\vec{\mathbf{E}}$ is parallel to the walls, <u>the standing waves must have nodes at $x = 0$ and $x = a$</u>
- The electric field for the standing waves is described by

  $E(x,\ t) = E_0 \sin(2\pi x/\lambda)\ \sin(2\pi\nu t)$

- Therefore, the waves will have nodes at $2x/\lambda = n$ $(n = 0, 1, 2, \ldots)$
- At $x = a$, it has to be verified: $2a/\lambda = n$ $(n = 1, 2, \ldots)$
- This determines a set of allowed values for the wavelength λ

Classical theory of cavity radiation

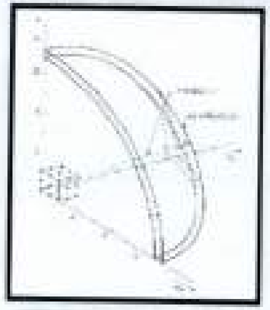
Rayleigh-Jeans calculations

- Working in terms of frequency instead of wavelengths we have: $\nu = cn/2a$ ($n = 1, 2, \ldots$)
- We now consider, using the diagram below, the number of allowed frequencies in the interval $[\nu, \nu + d\nu]$, or $N(\nu)\,d\nu$.
- Taking into account that we must apply a factor of two to count the two independent polarization states for each wave, we have:

$$N(\nu)\,d\nu = \frac{4a}{c}\,d\nu \qquad (7)$$

Classical theory of cavity radiation

Rayleigh-Jeans calculations: 3D case



- For the 3D case, we follow the same procedure, counting the number of points within a shell of surface $\pi(2a/c)^2\nu^2$ and thickness $(2a/c)d\nu$
- After working out few mathematical detail (check Eisberg's book), we arrive to:

$$N(\nu)\,d\nu = \frac{8\pi V}{c^3}\nu^2\,d\nu \qquad (8)$$

being $V = a^3$ the volume of the cavity.

Classical theory of cavity radiation

Rayleigh-Jeans calculations: classical kinetic theory

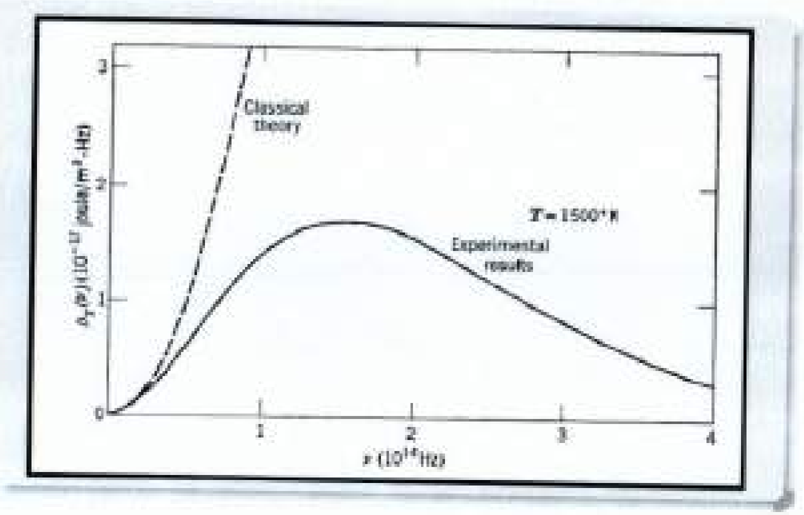
- The final stage will be to evaluate the average energy contained on each standing wave of frequency v.
- Applying classical statistical physics, for a system with a large number of physical entities in thermal equilibrium, the law of equipartition of energy applies.
- The average *kinetic* energy per degree of freedom is then $kT/2$, with the Boltzmann constant k being $k = 1{,}38 \cdot 10^{-23} J/K$.
- For a standing electromagnetic wave, the total energy is twice the kinetic energy. Then, we have an average energy per wave $\bar{s} = kT$, and we can now finally evaluate the energy density inside the cavity $\rho(v)$ as:

$$\rho(v)\, dv = \frac{N(v)\,\bar{s}}{V}\, dv = \frac{8\pi v^2 kT}{c^3}\, dv \tag{9}$$

which is the **Rayleigh-Jeans formula for blackbody radiation**.

- At high frequencies, the formula diverges, which constitutes the "ultraviolet catastrophe". To overcome this, we will explain in the next chapter how, by changing the assumptions in classical physics about the energy content of standing waves, Planck arrives to a correct solution of the problem.

Ultraviolet catastrophe



Rama chandra patra
11.12.17

Department of Physics, Pattamundai College.

Students Attendance on the seminar

"Ultra Violet Catastrophe" on Dt. 11.12.2017

Sl.No.	Roll No.	Signature of the Student
1	BS-17-120	Nibedita Patra.
2	BS-17-128	Sukalyani Behura.
3	BS17-129	Bijayalaxmi Sarangi
4	BS17-032	Laxmipriya sahoo
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PATTAMUNDAI COLLEGE, PATTAMUNDAI
SEMINAR ON :
ULTRAVIOLET CATASTROPHE
Organised by :
Department of Physics
Person : RAMA CHANDRA
The Ultraviolet Catastrophe
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