

Manipal University Jaipur

Department of Physics

Webinar On Blend of Physics & Materials

Report 2

Title of Talk: X-ray scattering studies of BaTiO₃ based ferroelectrics

Speaker



**Dr. Dinesh Kumar Shukla, Scientist E
Novel Materials Laboratory
UGC-DAE Consortium for Scientific Research**


Indore

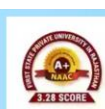
Convener of the Event: Dr. Sushil Kumar Jain Date of the Event: 23/06/2021

Flyer of the event



**MANIPAL UNIVERSITY
JAIPUR**





Speaker 1



Eduardo Lugo
Associate Researcher
Faubert Lab, School of Optometry, Quebec,
Canada

Topic: Photonic Crystals Oscillators
Time: 10:15 AM to 11:00 AM

Link for registration:
<https://forms.gle/KmaA2jXVVJ6aJ6ko8>

***e-certificate to all participants**

Decennial Year Celebration
Blend of Physics and Materials
An Online Webinar Series Hosted
by
Department of Physics
(For UG/PG/Research Scholars & Faculty members)

Join us on 23rd June 2021
From 10:00 AM to 12:00 PM
(Online Platform: MS Team)

About the Department of Physics
The Department of Physics, School of Basic Sciences was established at Manipal University Jaipur in 2011. The academic programs of the department include BSc (Hons)-Physics, MSc (Physics) and PhD. The department conducts teaching courses for students of engineering disciplines and graduate/postgraduate courses for basic science students with Physics as major subject. The department is also involved in conducting interdisciplinary studies and research, with engineering and other basic science departments courses.

For more information
<https://jaipur.manipal.edu/ios/schools-faculty/schools-list/obs/dept-of-physics.htm>

Speaker 2



Dr. Dinesh Kumar Shukla, Scientist E
Novel Materials Laboratory
UGC-DAE Consortium for Scientific Research
Indore

Topic: X-ray scattering studies of BaTiO₃ based ferroelectrics
Time: 11:00 AM to 11:45 AM

Convener of the Event
Email: sushilkumar.jain@jaipur.manipal.edu
Mob no. 8003599914, 9828034055

About the Speaker

Dr. Dinesh Kumar Shukla

Obtained Ph.D. (Physics) from AMU, Aligarh, in strong collaboration with IUAC, New Delhi, India.

Post-doctoral research at PETRA III, DESY, Hamburg, Germany, in the field of magnetic X-ray diffraction.

Extensive experience of resonant and non-resonant x-ray scattering experiments on complex oxides, experiments have been performed at various synchrotron sources across the world.

More than 12 years of post-Ph.D. research experience.

Currently working as a Scientist at UGC-DAE CSR, Indore.

Awards:

SERB Early career research award,
DST-Inspire faculty award,
UGC-Assistant professorship

To his credit Dr. Shukla has about 100 research publications with more than 1280 citations and an H index of 21 (source: Google scholar) involving studies broadly in the field of experimental condensed matter Physics.

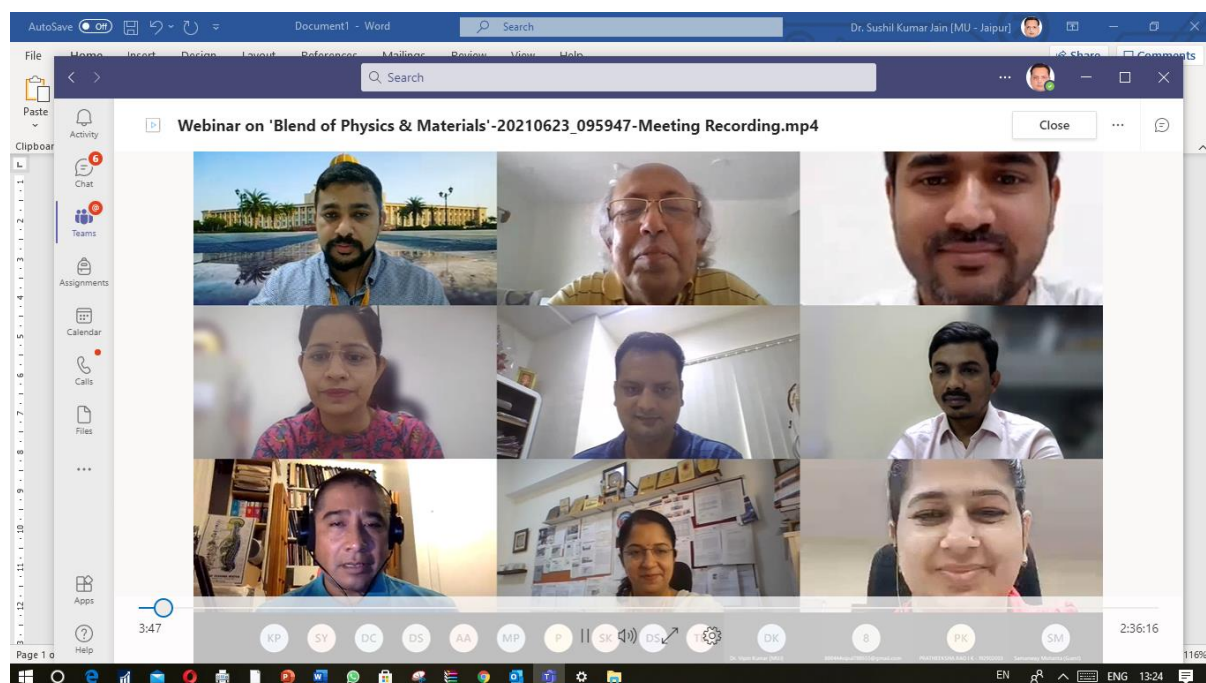
Abstract of Talk

Dr. Shukla Mentioned that the Novel Materials Laboratory at UGC-DAE Consortium for Scientific Research, Indore is mainly dedicated to design, growth and characterizations of multifunctional oxide materials useful for energy harvesting and for advanced technological applications. Main emphasis of his group is towards understandings of the structure-property relationships in these materials. They utilize synchrotron based resonant and non-resonant X-ray scattering and other X-ray spectroscopic methods and try to understand the microscopic origin of exotic behaviour in complex oxides.

They also engaged in in-house developments of characterizations methods.


Dr. Shukla discussed about the X-ray scattering studies of BaTiO₃ based ferroelectrics. He discussed the characterization techniques and other measurements.

Photographs of the event



AutoSave 09 Report of BOPM Search Dr. Sushil Kumar Jain (MU - Jaipur)

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 **X-ray scattering studies of BaTiO₃ based ferroelectrics**

Dinesh K. Shukla

Novel Materials Laboratory
UGC-DAE Consortium for Scientific Research, Indore
dkshukla@csr.res.in

Blend of Physics & Materials, Manipal University Jaipur, June 23, 2021

1:16:00 2:36:16

Magnetic measurements

- Vibrating sample magnetometer (VSM; 2K/14T)
- SQUID magnetometer (2K-320K; 7T)
- AC Susceptibility (80-300K/100e)
- Magneto-Optic Kerr effect (MOKE)
- In-situ MOKE
- SQUID- VSM (2K/7T)

Different Thin Films Facilities:

1. Electron Beam Evaporation,
2. Ion Beam Sputtering,
3. Magnetron Sputtering,
4. Pulsed Laser Deposition,
5. Langmuir Blodgett

Microscopic Techniques

- Transmission Electron Microscope with EDAX
- Scanning Electron Microscope (SEM) with EDAX
- Scanning probe microscope (SPM), UHV STM
- Low temperature and high field SPM (5K/9T)
- Confocal Microscope

X-ray spectroscopic facilities at Indus synchrotron, RRCAT

Spectroscopic Techniques

- Photo-electron spectroscopy (XPS, UPS)
- Secondary Ion mass spectroscopy (SIMS)
- Inverse Photo-emission spectroscopy (IPS)
- Electron Spectroscopy for Chemical Analysis (ESCA)
- Mossbauer spectroscopy (2K/8T)
- Micro Raman spectroscopy (LT)
- UV-Visible spectroscopy
- FTIR
- Dielectric Spectroscopy: Broadband Impedance Analyzer

Thermal measurements

- Temperature dependent measurements (resistivity/Specific heat)
- Temperature dependent measurements (resistivity/specific heat (1.5K/8T))
- Temperature based resistivity/thermoelectric power (4.2K)
- PE loop tracer
- Dielectric Relaxation Spectroscopy
- Liquid He based resistivity/thermoelectric power (5-330K)
- Low Temperature Thermal Conductivity
- Temperature-Modulated Differential Scanning Calorimeter

01:19:45 01:16:31

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Piezoelectric, thermoelectric, Multiferroics, and strongly correlated electron system

Current students

- Koushik
- Shikha
- Abinash
- Najnin

Past students

- Dr. Suhail
- Dr. Kamini
- Dr. Abdul

Phys. Rev. B **103**(10), 100205 (2021)
 Phys. Rev. B **102**, 094428 (2020)
 Phys. Rev. B **101**, 224430 (2020)
 Phys. Rev. B **101**, 220202(R) (2020)
 Phys. Rev. B **101**, 014108 (2020)
 Review of Scientific Instruments, **90**(11), 116101(2019)
 Phys. Rev. B **100**, 104106 (2019)
 Phys. Rev. B **98**, 075152 (2018)
 Applied Physics Letters, **113**(10), 102405(2018)
 Phys. Rev. B **95**, 144112 (2017)
 Applied Physics Letters, **110**(17), 173101(2017)

1:21:47

Films & TV

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Structure – property relationship

Charge +Q, Electric field E, Polarization P, Strain, Stress, Compression, Expansion, Piezoelectric, Pyroelectric, Ferroelectric, Dielectric

32 Crystallographic Point Groups

- 11 Centrosymmetric
- 21 Non-centrosymmetric
- 20 Piezoelectric
 - 10 Pyroelectric
 - 10 Non-pyroelectric
- 1 Non-Piezoelectric (group 432)

S. Trolier-McKinstry; Crystal chemistry of piezoelectric materials

Neumann's principle: The symmetry elements of any physical property of a crystal must include the symmetry elements of the point group of the crystal.

1:27:52

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$\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$ (PZT)

$(1-x)\text{Ba}(\text{Zr}_{0.2}\text{Ti}_{0.8})\text{O}_3-x(\text{Ba}_{0.7}\text{Ca}_{0.3})\text{TiO}_3$

Phys. Rev. Lett. 103, 257602 (2009); > 2100

M Acosta et al., Appl. Phys. Revs. 4, 041305 (2017).
 F. Jona and G. Shirane, Ferroelectric Crystals (Dover Publications, 1993).
 A. F. Devonshire, London, Edinburgh Dublin Philos. Mag. J. Sci. 40, 1040 (1949).

Alkaline Niobate, Saito et al., (2004)

1:35:02 2:36:16

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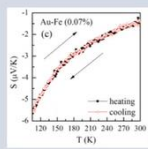
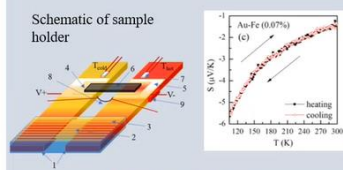
X-ray absorption spectroscopy (XAS)

XANES/EXAFS

Pd-foil: Pd K-edge

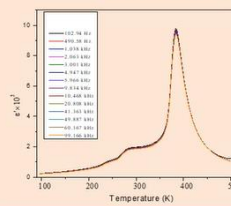
Advantageous over other structural tools..!!

1:48:03 2:36:16



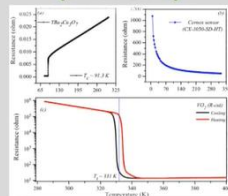
A. Ahad and D. K. Shukla,
RSI 90, 116101 (2019).

Dielectric spectroscopy (5 to 700 K)

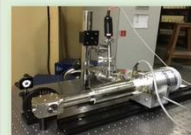


Temperature behaviour of dielectric constant of a tetragonal composition of lead free BZT-BCT [(1-x)Ba(Zr_{0.2}Ti_{0.8})O₃-x(Ba_{0.7}Ca_{0.3})TiO₃] piezoceramics:

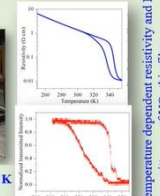
**Four probe resistivity
(5 to 700 K)**



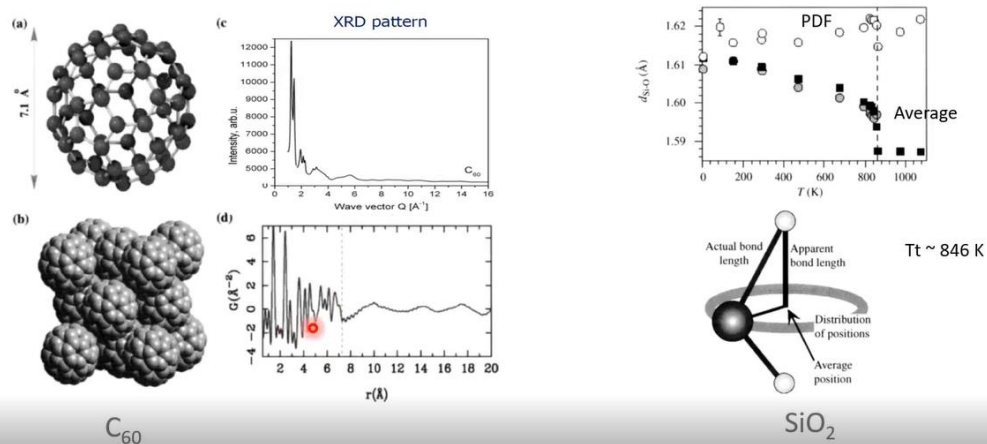
CCR (9 to 350 K) suitable for optical measurements



CCR : Temperature range : 8.5 K
- 350 K



Examples of PDF outcome



Underneath the Bragg peaks, Takeshi Egami & Simon Billinge

01:56:02

00:40:14

DC DS SM MP

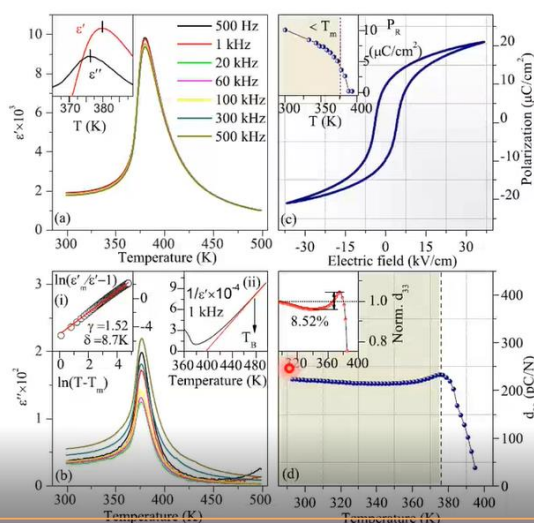
Dr. Rishi Nathawat [MS - Jaipur] Dr. Sushil Kumar Jain [MS - Jaipur]

Dr. Usha Vidyaveerakkar [MS - Jaipur] Dr. Ashima Bagaria [MS - Jaipur] Dr. Vign Kumar [MS]

EN ENG 14:51

Co-existence of local structural heterogeneities and long-range ferroelectricity in Ca, Zr doped BaTiO₃

PRB letter 103, L100205 (2021).



Acknowledgements:

Funding:



Collaborators:



100th anniversary of the discovery of ferroelectricity experimentally:

Joseph Valasek reported permanent polarization and hysteretic switching in Rochelle salt, potassium sodium tartrate tetrahydrate, which was known to exhibit piezoelectric behaviour. Valasek, J. *Phys. Rev.* 17, 475–481 (1921).

Consortium for Scientific Research, Indore
www.csrusportal.com

Attendance list

Full Name	User Action	Timestamp
Dr. Sushil Kumar Jain [MU - Jaipur]	Joined	6/23/2021, 9:39:47 AM
Sandhya Kattayat	Joined before	6/23/2021, 9:39:47 AM
Sandhya Kattayat	Left	6/23/2021, 11:23:44 AM
Dr. Anoop Kumar Mukhopadhyay [MU - Jaipur]	Joined	6/23/2021, 9:41:57 AM
Dr. Anoop Kumar Mukhopadhyay [MU - Jaipur]	Left	6/23/2021, 10:31:12 AM
Dr. Ashima Bagaria [MU - Jaipur]	Joined	6/23/2021, 9:43:50 AM
eduardo.lugo (Guest)	Joined	6/23/2021, 9:45:57 AM
eduardo.lugo (Guest)	Left	6/23/2021, 9:46:00 AM
eduardo.lugo (Guest)	Joined	6/23/2021, 9:47:16 AM
eduardo.lugo (Guest)	Left	6/23/2021, 9:47:18 AM
eduardo.lugo (Guest)	Joined	6/23/2021, 9:47:38 AM
eduardo.lugo (Guest)	Left	6/23/2021, 9:47:39 AM
Samriddh Kumar Singh [ECE - 2020]	Joined	6/23/2021, 9:47:17 AM
Samriddh Kumar Singh [ECE - 2020]	Left	6/23/2021, 9:47:21 AM
palaktarachandani (Guest)	Joined	6/23/2021, 9:48:39 AM
palaktarachandani (Guest)	Left	6/23/2021, 10:34:37 AM
palaktarachandani (Guest)	Joined	6/23/2021, 10:34:58 AM
Eduardo Lugo (Invité) (Guest)	Joined	6/23/2021, 9:53:16 AM
Eduardo Lugo (Invité) (Guest)	Left	6/23/2021, 11:21:09 AM
Dr. Uvais Valiyaneerilakkal [MU - Jaipur]	Joined	6/23/2021, 9:53:36 AM
mpatel1439 (Guest)	Joined	6/23/2021, 9:53:45 AM

Dr. Vipin Kumar [MUJ]	Joined	6/23/2021, 9:54:16 AM
Dr. Anupam Sharma [MU - Jaipur]	Joined	6/23/2021, 9:54:32 AM
Dr. Anupam Sharma [MU - Jaipur]	Left	6/23/2021, 11:39:00 AM
Dr. Rashi Nathawat [MU - Jaipur]	Joined	6/23/2021, 9:54:41 AM
888444vipul788555@gmail.com (Guest)	Joined	6/23/2021, 9:54:44 AM
Samanway Mohanta (Guest)	Joined	6/23/2021, 9:55:22 AM
Dr. Lalita Ledwani [MU - Jaipur]	Joined	6/23/2021, 9:57:05 AM
Dr. Lalita Ledwani [MU - Jaipur]	Left	6/23/2021, 10:31:40 AM
pratibha singla (Guest)	Joined	6/23/2021, 9:57:06 AM
pratibha singla (Guest)	Left	6/23/2021, 9:59:08 AM
Dr. Satyapal Singh Rathore [MU - Jaipur]	Joined	6/23/2021, 9:57:21 AM
Dr. Satyapal Singh Rathore [MU - Jaipur]	Left	6/23/2021, 11:30:08 AM
pratheeksha.k2 (Guest)	Joined	6/23/2021, 9:58:47 AM
pratheeksha.k2 (Guest)	Left	6/23/2021, 11:07:56 AM
Dinesh Shukla (Guest)	Joined	6/23/2021, 10:00:26 AM
Dr Veenu Sisodia (Guest)	Joined	6/23/2021, 10:00:53 AM
Sagar Yadav [ECE - 2020]	Joined	6/23/2021, 10:01:22 AM
Sagar Yadav [ECE - 2020]	Left	6/23/2021, 10:08:41 AM
Dr. Saikat Chattopadhyay [MU - Jaipur]	Joined	6/23/2021, 10:01:24 AM
Tara Chand Badiwal [Ph.D (SBS) - 2021]	Joined	6/23/2021, 10:01:36 AM
Tara Chand Badiwal [Ph.D (SBS) - 2021]	Left	6/23/2021, 11:08:30 AM
Tara Chand Badiwal [Ph.D (SBS) - 2021]	Joined	6/23/2021, 11:10:08 AM
Tara Chand Badiwal [Ph.D (SBS) - 2021]	Left	6/23/2021, 11:20:47 AM
Tara Chand Badiwal [Ph.D (SBS) - 2021]	Joined	6/23/2021, 11:34:22 AM
Ashutosh Anand (Guest)	Joined	6/23/2021, 10:02:06 AM
Ashutosh Anand (Guest)	Left	6/23/2021, 10:31:32 AM
krishnabp204 (Guest)	Joined	6/23/2021, 10:02:56 AM
krishnabp204 (Guest)	Left	6/23/2021, 10:04:30 AM
krishnabp204 (Guest)	Joined	6/23/2021, 10:29:42 AM
krishnabp204 (Guest)	Left	6/23/2021, 10:43:33 AM
Arpana Pal Sharma [PhD - 2020]	Joined	6/23/2021, 10:05:15 AM
devishasanandiya0638 (Guest)	Joined	6/23/2021, 10:05:16 AM
VIKRAM SHREE VATS (Guest)	Joined	6/23/2021, 10:05:54 AM
VIKRAM SHREE VATS (Guest)	Left	6/23/2021, 10:12:31 AM
nitin chaudhary (Guest)	Joined	6/23/2021, 10:09:25 AM
cool91rajesh@gmail.com (Guest)	Joined	6/23/2021, 10:11:43 AM
cool91rajesh@gmail.com (Guest)	Left	6/23/2021, 10:40:45 AM
hiralodedra103 (Guest)	Joined	6/23/2021, 10:12:55 AM
hiralodedra103 (Guest)	Left	6/23/2021, 10:37:36 AM
vsvats72 (Guest)	Joined	6/23/2021, 10:14:07 AM
pratibha singla (Guest)	Joined	6/23/2021, 10:16:20 AM
pratibha singla (Guest)	Left	6/23/2021, 10:18:44 AM

SMRITI SHILPAM - 192902004	Joined	6/23/2021, 10:16:53 AM
SMRITI SHILPAM - 192902004	Left	6/23/2021, 10:27:43 AM
Chandan Singh	Joined	6/23/2021, 10:18:23 AM
Chandan Singh	Left	6/23/2021, 11:35:31 AM
Dr. Nilanjan Halder [MU - Jaipur]	Joined	6/23/2021, 10:20:15 AM
pratibha singla (Guest)	Joined	6/23/2021, 10:20:18 AM
pratibha singla (Guest)	Left	6/23/2021, 10:21:41 AM
Dr. Pushpendra Kumar [MU - Jaipur]	Joined	6/23/2021, 10:21:09 AM
Dr. Pushpendra Kumar [MU - Jaipur]	Left	6/23/2021, 10:41:03 AM
pratibha singla (Guest)	Joined	6/23/2021, 10:22:04 AM
pratibha singla (Guest)	Left	6/23/2021, 10:27:15 AM
pratibha singla (Guest)	Joined	6/23/2021, 10:28:36 AM
pratibha singla (Guest)	Left	6/23/2021, 10:38:48 AM
Ashima Sharma [PhD - 2020]	Joined	6/23/2021, 10:29:03 AM
Ashima Sharma [PhD - 2020]	Left	6/23/2021, 11:20:06 AM
Ashima Sharma [PhD - 2020]	Joined	6/23/2021, 11:21:56 AM
Ashutosh Anand (Guest)	Joined	6/23/2021, 10:34:06 AM
Abinash Tripathy (Guest)	Joined	6/23/2021, 11:19:30 AM