Physical Chemistry in India

Kankan Bhattacharyya

Where to Start?

- Strong Electrolytes, JC Ghosh, *J Phys Chem* **1915**, *19*, 720−733 (1st paper in JPC)
- Electric synthesis of Colloid, JN Mukherjee, JACS (**1915**)
- 1915: MSc & joined as Lecturer at Science College, Calcutta University
- 1914: Science College founded by Asutosh Mukherjee (Raman, SN Bose, MN Saha)

Schatz, JPC Lett 8 (2017) 312

Bhattacharyya, Ind J Hist of Sc 49 (2014) 371

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Early Period : 1915-1947 (Indian Independence)

Research and Institution Building

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- **SS Bhatnagar (1894-1955)**
- 1921: DSc, London with FG Donnan, BHU (1921-24), Punjab (1921-40),
- Magnetochemistry: patented a Balance (Hilger), Textbook, Emulsion
- First Secretary BSIR (1940) / DG, CSIR (1942), (Now 40 labs)

- **JC Ghosh (1893-1959)**
- Strong Electrolyte, Fisher Tropsch, Photochem, Raman Spectroscopy
- Dacca (1921-39), Director, IISc Bangalore (1939-49) & first IIT, Kharagpur (1950-54)

- JN Mukherjee (1893-1983)
- Colloid Chemistry, Micelles, surfactants, Soil Chemistry, Agricultural Chemistry
- Director General, Imperial Agr Res Inst (later IARI, Pusa), Green Revolution

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- **Formative Period**: (1947-1970)
- Creation of CSIR Labs, IITs
- Expansion of old Institutes

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Indian Assn for Cultivation of Science (IACS, 1876-)

- **Raman worked 1907-33, Raman Effect in 1928 and Nobel, 1930**

KS Krishnan (1898-1961) at IACS

- Magnetic anisotropy of inorganic crystals
- 1939: "Jahn-Teller theorem and arrangement of water molecules around paramagnetic ions," implications in anisotropy & birefringence (*Nature*, 1939).

BC Guha at IACS

- ***Molecular Magnetism,*** **Olivier Kahn**: "The magnetic interaction phenomenon within a molecule was discovered in 1951 by Guha [*Proc Roy Soc* 1951] and then by Bleaney & Bowers."
- anti-ferromagnetic interaction of two Cu (II) in copper acetate dimer

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POLYMER SCIENCE at Phys Chem Dept, IACS (MN Saha, first Director, 1948-)

- **SR Palit**: pioneered use solvent mixtures (co-solvency) for polymers, End Group Titration
- **Sadhan Basu**: Phenol as solvent for Nylon, Mol wt & titration of end group
- Free Radical polymerization : Basu and Palit
- **Pasupati Mukherjee** (IACS & later Wisconsin): Micelles, local polarity, pH……

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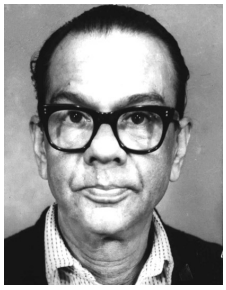

Sadhan Basu (1922-93)

- Versatile Genius: India's Linus Pauling

Bio-Physical Chemistry

- Viscosity of DNA: **Basu** (Nature, 1951 and Science, 1952)
- Optimum pH for Enzyme: **Basu** (Nature 1952)

Quantum Chemistry (Introduced Teaching of Quantum Chemistry)

- Free electron MO, Huckel Theory, Tomonaga Gas model
- Orientation of Substituents in Aromatics (JCP 1954), Free Electron Theory of Diels-Alder Reaction (JCP 1955), Group Localization & polarography (Nature, 1957,1958), Tropolone, phthalocyanine
- Founding Editor, *International Journal of Quantum Chemistry*

Crystal Spectra (with A Chakravorty, Nature 1959, 1960**)**

Charge Transfer Spectra (with M Chowdhury, Trans Farad Soc 1960**)**

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Prof Sadhan Basu (1922-93)
The most versatile Physical Chemist

- Polymer Chemistry
- Biophysical Chemistry
- Quantum Chemistry
- Spectroscopy
- Teaching

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Contributions of Sadhan Basu

Polymer (1947-)
- Phenol:solvent for nylon
- End group titration
- Chain Transfer

Biophysical (51-52)
- Viscosity of DNA
- pH dep. of enzyme
- Nature & Science

Quantum Chem (1954-)
- Free Electron theory
- Phthalocyanine
- E_a of Diels-Alder Rxn
- Solvent effect
- Para localizn. & $E_{1/2}$

Spectroscopy (1958-)
- Polarized Abs: Crystal field splitting
- Charge Transfer

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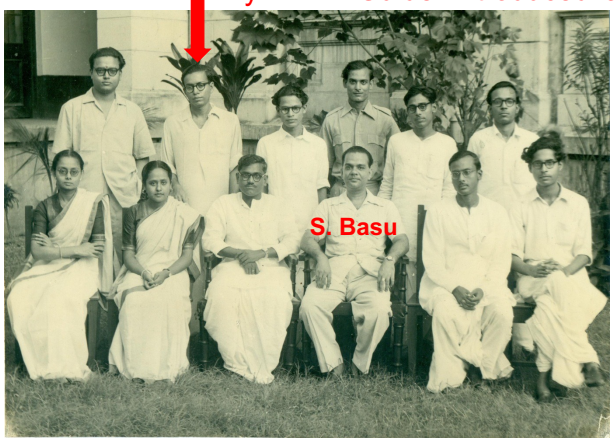
Teaching

- Introduced Quantum Chemistry in India
- 3 of his students got Bhatnagar Prize

(A Chakravorty, M Chowdhury, S Poddar)

My Ph. D. Guide: Introduced laser in India



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Chemistry Nobel 2013 & A Missed Indian Hero

"Computer Simulation *for Complex Chemical Systems*"
Karplus, Levitt, Warshel

Aneesur Rahman

Born: 1927 (Hyderabad) Died: 1987 (Minnesota)

- **Tripos (Cambridge), DSc (1953, Leuven)**
- **Osmania (1953-57), TIFR (1957-60)**
- **Argonne, MD Simulation, xenon (1964), first Protein (1976)**
- **Lattice Gauge Theory**
- **Collaborators: Klein, Parinello….**

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IIT Kanpur (1959-)

- CNR Rao (1934 -), joined IIT-K in 1963, ***Bharat Ratna***
- Solid State Chemistry, Material Sc, Nanoscience
- IIT K, IISc, JNCASR

- PT Narasimhan (1928 – 2013)
- Computational Chemistry, NMR, NQR

- D Balasubramanian (1939 –)
- Biophysical Chemistry, Ocular Science

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Creation of Dept of Sc & Technology in 1971: A big Boost

- Food Crisis: India imported wheat from USA 1964, -65 & -66 under PL-480
- Green Revolution: In 1966, India started using Borlaug's Hybrid Seeds
- 1970: Norman Borlaug got Nobel
- 1971: PM Indira Gandhi created DST at the PL-480 Godown

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Laser Spectroscopy (1975 -)

Mihir Chowdhury (1937- 2017)

- Crystal Spectroscopy at Cryogenic Temp, Mag Field Effect
- Two Photon Absorption, Chemical Dynamics, Supersonic Beam

JP Mittal (1940 -)

- Photochemistry, Radiation Chemistry
- LINAC based pulse radiolysis, nano-to-femtosecond flash photolysis
- Isotope separation by IR multiphoton, Femtosecond

N Periasamy (1946 -)

- Picosecond time resolved spectroscopy
- Diffusion controlled electron transfer, TRANES, Bio-physical
- J-aggregates, Micelles, Materials, OLED

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Quantum Chemistry (1975 -)

BM Deb (1942 -)

- Force Concept, Role of HOMO in Molecular Shape
- Density Functional Theory, Quantum Fluid Dynamics

D Mukherjee (1946 -)

- Many Body Perturbation Theory
- Theoretical Electron Spectroscopy

N Sathyamurthy (1951 -)

- Molecular Reaction Dynamics, Computational Chemistry
- Water Clusters, Nanoconfinement, Hydrogen Bonding, **IISER Mohali**

ED Jemmis (1951 -)

- Jemmis mno rules, polyhedral boranes, allotropes of boron
- Reactions of transition metal organometallics, weak H-bond, **IISER Trivandrum**

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Other Theoretical Chemists: SR Gadre, KD Sen, S Ramasesha, S Ghosh…..

Biman Bagchi (1954 -)

- Statistical Mechanics, Theory and Simulations
- Ultrafast Chemical Dynamics in Liquids
- *Biological Water,* Chiral Self-Assembly, Protein Folding,
- 2021 ACS Hildebrand Prize, Humboldt Prize, National Sci Chair

Later Theoretical Chemists: S Pal, PK Chattaraj, A Chandra, SK Pati…..

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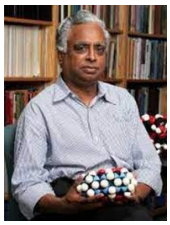
Modern Photochemistry in India

MV George
(1928-2019)

- 30 yrs each at IIT Kanpur and RRL Trivandrum
- Introduced modern Photochemistry with lasers
- Mechanism of Organic photoreactions, flash photolysis
- Organic Materials



V Ramamurthy
(1946-)

- **1978-87**: IISc Bangalore, 16 PhD, 120 papers, spl issue on Organic Chemistry in Anisotropic Media, for Tetrahedron
- **1987-94**: Du Pont, *Photochemistry in Organized and Constrained Media, Spl issue of Chemical Review on Photochemistry (1993)*
- Tulane Univ and Miami University, Collaboration with Indians

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Growth of Physical Chemistry in India

Schatz, JPC Lett 8 (2017) 312

- Papers per year in JPC from India

  24 in **1990**

  ~100 in **2003**

  ~300 in **2010**

  410 in **2016**

  489 in **2020**

- Indian Editors in JPC: three Senior Editors, >12 in Advisory Board
- Four special issues in honor of Indian Physical Chemists

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Photochemistry Research Unit, RRL, Trivandrum

- **Suresh Das, (1987-)**
- Liquid Crystals, Squaric acid, Organic materials

- **A AjayaGhosh, (1990-)**
- Polymer, Organic materials, NIR days
- Gold Nanoparticles, Drug Delivery

- **K George Thomas, (1990-)**
- Gold Nanoparticles, ultrafast processes

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- **Kankan Bhattacharyya at IACS (1987-2016), IISER Bhopal (2016-)**
- **1987**: Dynamics in Nano cavity (TICT, cyclodextrin, Chem Rev, **1993)**
- **1993-95: Picosecond,** Surface Second Harmonic Generation
- **1996**: Solvation dynamics, biological water 100 times slower than ordinary water, ***implications,*** Chem Rev 2000, JPC Feature 2000, Acc Chem Res 2003…
- **2004** femtosecond, **2007** confocal, **2011** Live cell Microscopy, JPC Feature (2018)

- **Anunay Samanta, Univ of Hyderabad (1990-)**
- Solvation dynamics in ionic liquids
- Metal ion sensors
- Femtosecond abs and emission: Perovskites
- Confocal Microscopy and FCS: DNA

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- **G Krishnamurthy, TIFR (1982-)**
- T-jump and ultrafast laser spectroscopy
- Proton Transport across membranes, raft on cell surfaces, protein folding
- Collaborators: J Udgaonkar, Madan Rao, S Mayor
- **Amitabha Chattopadhyay, CCMB, Hyderabad (1990-)**
- Membrane and receptor Biology, G protein coupled receptor (GPCR)
- Red Edge Excitation Shift: Spatial Resolution
- **Sudipt Maiti, TIFR (1999-)**
- Single Molecule, FCS, TIRF
- Aggregation of Amyloid fibrils
- Senior Editor JPC (2020-)

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- **Siva Umapathy, IISc Bangalore (1990-)**
- Time Resolved Resonance Raman: Pico and Femtosecond
- Ultrafast Raman Loss
- **DK Palit, BARC (1988 -)**
- Femtosecond Abs
- Organic photochemistry
- **HN Ghosh, BARC (1990-)**
- Femtosecond Abs
- Nano-particles, photovoltaics
- **JA Alam, BARC (2006--)**
- Surface non-linear spectroscopy (SSFG)
- Lipids, proteins…..

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- **Sobhan Sen, JNU, Delhi (2006-)**
- Femtosecond: Solvation Dynamics in DNA (two JACS 2010 & 2011))
- FCS: Growth of nanoparticles (JACS 2012)
- DNA G-quadruplex, Lipids

- **ASR Koti, TIFR (2006-)**
- Force Microscopy
- Proteins and biological systems

- **Jyotishman Dasgupta, TIFR (2006-)**
- Femtosecond: electron solvation
- Inorganic systems

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High Resolution Spectroscopy in Jets

- PK Chakrabarti: BARC (1980-)
- M Chowdhury: IACS (1990-)
- S Wategaonkar, TIFR (1994-)
- E Arunan, IISc Bangalore (1992-)
- T Chakraborty, IIT-K & IACS (1994)
- G Naresh Patwari, IIT Bombay (2006-)

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IIT-s: Femtosecond and Microscopy

- **Nilmoni Sarkar, IIT Kharagpur (1998-)**
- Ionic liquid, Graphene, Lipid, protein

- **Anindya Dutta, IIT Bombay (2008-)**
- Nanoparticles
- Waterless Proteins

- **Pratik Sen, IIT Kanpur (2008-)**
- Ultrafast Non-radiative Processes (JACS)
- Proteins in crowded media, Perovskites

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Dramatic Expansion after 2006: IIT, IISER, NISER

- **Saptarshi Mukherjee, IISER Bhopal (2008-)**
- Picosecond & Confocal microscopy
- Fluorescent metal nano-clusters: DNA probe, metal ion sensor,…

- **Samrat Mukhopadhyay, IISER Mohali (2008-)**
- Femtosecond and Raman, Intrinsically disordered protein
- Liquid-liquid phase transition (JACS PNAS..)

- **Partha Hazra, IISER Pune (2008-)**
- Femtosecond, Carbon nanotube, Aggregation induced enhancement)

- **Pradipta Purakayastha & Prasun Mandal, IISER Kolkata (2007-)**
- Picosecond, and microscopy: biological systems, nano-particles, ionic liquids

- **Subhadip Ghosh, Moloy Sarkar, Himansu Biswasl, NISER (2009-)**
- Picosecond, Femtosecond, and microscopy: biological systems, nano-partiicles, ionic liquids

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SN Bose Centre, Kolkata

- **Ranjit Biswas (2003-)**
- Picosecond, Dielectric Relaxation, Simulation
- Ionic Liquids, Deep Eutectic

- **Manik Pradhan (2006-)**
- Cavity Ring Down Spectroscopy: Path Length ~ Km
- Breath: Traces of Acetone, Ammonia: Medical Dignosis

- **Samir Pal (2004-)**
- Femtosecond, Materials, Biomedical

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Present Status of Physical Chemistry in India

- Enormous Variety, Many Active workers, World-class facilities
- Temporary setback because of Pandemic & Fund crunch
- But Future is Bright

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