复旦大学物理系 Colloquium

Time: 14:00, Tuesday, 2026.09.15

Location: C108, Jiangwan Physics Building

A lifetime fascination with high-Tc superconductivity

Prof. Ivan Bozovic

Shanghai Advanced Research in Physical Sciences (SHARPS)

Abstract: I have been beguiled by high-temperature superconductivity (HTS) ever since I stumbled upon the famous Ginzburg's list of the most important open problems in physics in 1971; HTS was high on the list as his topic #2. Early on I did some theory; e.g., I predicted that Li:BeH2 should feature a very strong (nonadiabatic) electron-phonon coupling and HTS. Then HTS was discovered for real, in cuprates, and I jumped on that right away. I wrote a bunch of optics and Raman papers but soon realized that what we can learn from these spectra about HTS is limited. Moreover, I concluded that to progress we needed to improve and perfect synthesis. My focus thus shifted to atomic-layer-by-layer molecular beam epitaxy (ALL-MBE), first at Varian, then at Oxxel, and eventually at BNL and Yale. ALL-MBE synthesis yields the highest-quality HTS films, heterostructures, and superlattices. The crux is in detailed material characterization, and that called for a lot of equipment building and development. I experimented with coupling ALL-MBE systems to TOF-ISARS, ARPES, STM, LEEM/LEED/PEEM, in situ transport and magnetization measurements, etc. My group also found a way to measure the London penetration depth with 1% absolute accuracy, introduced angle-resolved transverse resistivity (ARTR) and magnetoresistance (ARTMR) techniques, and achieved ±1 mK thermal stabilization of closed-cycle cryocoolers.Our grand aspiration was to produce the best samples anywhere and make the most accurate measurements of the physical properties most relevant for HTS — and then leverage that to test the most important HTS theories. These included the excitonic pairing scenarios proposed by Bardeen, Ginzburg, and Little, the Marginal Fermi Liquid theory , the SO(5) theory of S-C. Zhang, and, more recently, the dirty BCS-FL models of the demise of HTS with overdoping. Next, we showed that in cuprates Tc scales with the superfluid density, rather than with the interaction strength and that the insulating state behaves like a quantum charge-cluster glass. The "normal" metallic state is nematic and (at some doping) shows T- and B-linear resistivity, unexpected in a gas of charged (quasi)particles. We also detected preformed electron pairs well above Tc. These experimental results were so incisive and restrictive that they ruled out almost the entire corpus of HTS theories, models, and scenarios.On the positive side, we discovered, at BNL, interface HTS confined to a single CuO2 layer – the thinnest known superconductor, yet with Tc equal to, or higher than in bulk LSCO. We also discovered, at Yale, two new 2D quantum materials, borophene and beryllene, new allotropes of B and Be.In the rest of talk, I will describe several incisive new experiments addressing the burning questions in the physics of HTS in cuprates and nickelates. The results are so unexpected that they may reset the field, imposing very tight constraints on the correct theory yet to be formulated. In particular, they point to exotic charge transport by collective excitations, the relevance of a high-energy scale, and ultra-strong (non-adiabatic) coupling of electrons to specific lattice distortions.

Biography: Ivan Bozovic received his Ph.D. in Solid State Physics from Belgrade University, Yugoslavia, where he was later elected a professor and the Physics Department Head. In 1985 he moved to the USA, working at Stanford University and the Varian Research Center in Palo Alto, California, till 1999. He worked three years in Oxxel, Bremen, Germany, and in 2003 joined Brookhaven National Laboratory, as the MBE Group Leader and later, also as a Distinguished Scientist. Since 2014, he was also an Adjunct Professor at Yale University. In November 2024, he joined Shanghai Advanced Research in Physical Sciences (SHAPRS) Institute.
He is a Member of the European Academy of Sciences, a Foreign Member of the Serbian Academy of Science and Arts, Professor Honoris Causa of the University of Montenegro, a Fellow of the American Physical Society (APS), and a Fellow of the International Society for Optics and Photonics (SPIE). He received the APS McGroddy Prize for Materials Physics, the Bernd Matthias Prize for Superconducting Materials, the SPIE Technology Award, M. Jaric Prize, International Carrier Achievement on Superconductivity Award, etc. He was elected as Max Planck Lecturer, Van der Waals Lecturer, and (twice) Gordon and Betty Moore Foundation Principal Investigator.Ivan's research interests include fundamental physics of condensed states of matter, novel electronic phenomena including unconventional superconductivity, innovative methods of thin film synthesis and characterization, and nano-scale physics. He published 11 research monographs and over 350 research papers, including over 30 in Science and Nature journals.