

TCSUH SPECIAL SEMINAR

Ranga Dias

Unearthly Materials Inc., 322 Blossom Road, NY 14610 USA

Tuesday, March 25, 2025

12:00 p.m. – 1:00 p.m.

In Person: Houston Science Center (HSC), Room 102 (*sandwiches provided*)

Toward Ambient Superconductivity

ABSTRACT: The pursuit of room-temperature superconductivity (RTS) has been a longstanding challenge in condensed matter physics since Kamerlingh Onnes' discovery of superconductivity in elemental mercury at 4.2 K over a century ago [1]. The profound implications of RTS—spanning energy transmission, quantum electronics, and advanced transportation systems—have driven relentless research efforts. Over the past decade, the field has been dominated by high-pressure compression techniques, which have led to significant progress in the realization of high-temperature superconductivity. The concept of chemical precompression [2] in hydrogen-dominant alloys has been at the forefront of these advances, yielding superconducting transition temperatures (T_c) near the freezing point of water in rare-earth hydrides under extreme megabar pressures [3,4].

Building upon our 2023 discovery of nitrogen-doped lutetium hydride as a high-pressure ($\sim 10,000$ atm), room-temperature superconductor, we have now achieved a landmark breakthrough by successfully reducing the required pressure from 10 kbar to ambient pressure (1 atm). In this study, we conducted a systematic investigation into the superconducting properties of nitrogen-doped lutetium hydride. Through precise stoichiometric control of nitrogen and hydrogen incorporation, we successfully realized superconductivity at ambient pressure, with a critical temperature (T_c) reaching 250K. The compound was synthesized under high-pressure, high-temperature conditions and subsequently stabilized for full recoverability at ambient conditions. The superconducting state was confirmed through the observation of a zero-resistance state and the Meissner effect. Comprehensive structural and spectroscopic analyses, including Raman spectroscopy, X-ray diffraction (XRD), and energy dispersive X-ray spectroscopy (EDX), were conducted to elucidate the material's composition and electronic structure. Furthermore, theoretical simulations provide insights into the underlying mechanisms governing its superconducting behavior. Finally, I will discuss future research directions, the potential applications of ambient-pressure superconductors, and their implications.

1. Onnes, H. K. The resistance of pure mercury at helium temperatures. *Commun. Phys. Lab. Univ. Leiden* **12**, 120 (1911).
2. Ashcroft, N. W. Hydrogen Dominant Metallic Alloys: High Temperature Superconductors? *Phys. Rev. Lett.* **92**, 187002 (2004).
3. Nugzari Khavashi-shyyer, Sasanka Munasinghe, Nilesch P. Salke, Sergio Villa-Cortés, Zhenxian Liu, Maddury Somayazulu, Russell J. Hemley, Ranga P. Dias "Observation of Conventional Superconductivity in Carbonaceous Sulfur Hydride at Near Ambient Temperature" <https://arxiv.org/abs/2302.08622>
4. Ranga P. Dias, "Stabilization of Superconducting Superhydrides" *Journal of Physics: Condensed Matter*, Volume 34, Number 18 (2021), Roadmap article on Advances towards Room Temperature Superconductivity, Invited article

Host: C. W. Chu **Persons with disabilities requiring special accommodations to attend should call 713-498-9703.**