

CYCLE DE CONFÉRENCES

Séminaire général de physique de l'Institut Polytechnique de Paris  
Département de physique de l'École polytechnique

# CHALLENGES, DISCOVERY, AND PROMISES OF METALLIC HYDROGEN



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In 1935, one of the earliest applications of quantum mechanics to condensed matter predicted the existence of metallic hydrogen stable at extremely high pressures. This remarkably simple state of matter — the Wigner crystal — consists of a lattice of protons immersed in a sea of electrons. In the 1970s, improved calculations suggested that hydrogen metallization under pressure would first occur through a phase of paired protons. Later theoretical work predicted extraordinary properties for metallic hydrogen, including high-temperature superconductivity and novel macroscopic quantum states such as mixed superconductivity-superfluidity or supersolidity.

For more than fifty years, the search for metallic hydrogen has been a central challenge in high-pressure physics and has driven major experimental advances. Few years ago, we

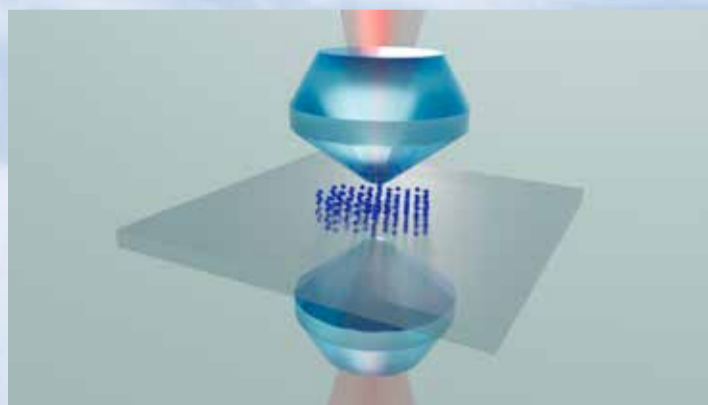
observed the formation of the paired metallic hydrogen phase above 430 GPa. In this lecture, I will present the experimental context and the path that led to this result.

The next challenge is to characterize the properties of this remarkable material. What can be done? Could metallic hydrogen be recovered at ambient pressure? The discovery of hydrogen-rich compounds known as superhydrides — which can be viewed as alloys of metallic hydrogen and conventional metals — may offer a way to bypass the need for extreme pressures, and perhaps even stabilize some metallic-hydrogen-like properties at ambient conditions. These materials already constitute a new class of high-temperature superconductors, and I will discuss the connection with metallic hydrogen. Finally, I will explain why metallic hydrogen is also essential for understanding planetary interiors.

THURSDAY  
JUNE 18,  
2026

**5:15 pm - 6:30 pm**  
**LECTURE HALL**  
**AMPHI GRÉGORY**

**ÉCOLE POLYTECHNIQUE**



*Observing Metallic  
Hydrogen compressed between two diamond anvils.*