Metallic dense hydrogen

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Hydrogen at ambient pressures and low temperatures forms a molecular crystal which is expected to display metallic properties under megabar pressures. This metal is predicted to be superconducting with a very high critical temperature Tc of 200-400 K. The superconductor may potentially be recovered metastably at ambient pressures, and it may acquire a new quantum state as a metallic superfluid and a superconducting superfluid. Recent experiments performed at low temperatures T<100 K showed that at record pressures of 300 GPa, hydrogen remains in the molecular state and is an insulator with a band gap of ∼2 eV. Given our current experimental and theoretical understanding, hydrogen is expected to become metallic at pressures of 400-500 GPa, beyond the current limits of static pressures achievable using diamond anvil cells. We found a way for producing metallic hydrogen by pressurizing hydrogen at room temperature. At 220 GPa, new Raman modes arose, providing evidence for the transformation to a new opaque and electrically conductive phase. Above 260 GPa, in the next phase, hydrogen reflected light well. Its resistance was nearly temperature-independent over a wide temperature range, down to 30 K, indicating that the hydrogen was indeed metallic. Releasing the pressure induced the metallic phase to transform directly into molecular hydrogen with significant hysteresis at 200 GPa and 295 K.