PHILIP ALLAN UPDATES

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Physics in the news

Metallic hydrogen discovered at last

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Look at the first column of the periodic table. All the elements except hydrogen are simple metallic solids, the so-called alkali metals that have just one active electron (mono-valent). The free electrons in metals allow them to conduct electrical charge with a positive temperature coefficient of resistivity (i.e. resistivity rises with increasing temperature as increased lattice vibrations impede the motion of the free electrons), and also give them their shiny appearance.

Hydrogen on the other hand is not only a gas at room temperatures, but normally exists as a diatomic molecule. As long ago as 1926 the crystallographer J. D. Bernal (1901–71) speculated that all non-metallic elements should become metals if subjected to sufficient external pressure. Subsequent calculations suggested that to convert hydrogen into a metal 25 GPa (25×10^9 Pa) would be needed, which was larger than could be achieved in laboratories at the time. 1 atmosphere pressure equals 105 Pa, so the predicted required pressure is equivalent to 250,000 atmospheres:

$1 \text{ atm} = 10^5 \text{ Pa}$

$25 \times 10^9 \text{ Pa} = 25 \times 10^9 / 10^5 \text{ atm}$

$= 2.5 \times 10^5 \text{ atm}$

Such pressures are likely inside the large gas giant planets, so if hydrogen does convert to a metal this will have a radical effect on their geology.

Making metallic hydrogen

Attempts to produce metallic hydrogen were reported in the 1990s but the results were at best inconclusive. The experimental difficulties are formidable. Hydrogen does not liquefy under its own vapour pressure until 20.3 K, becoming a non-metallic solid at 14.0 K. Attempts have been made to compress both the liquid and solid phases using diamond anvils. Recently, the first convincing results have been reported (*Nature*, 24 November 2011, p. 448). The key to the success was the realisation that hydrogen diffuses easily into diamond, rendering it brittle. This was prevented by coating the compression device with a thin layer of copper.

At 265 ± 5 GPa the hydrogen became a reflective metal. Although considerably higher than the early predictions it was achieved at a lower pressure than in some previous experiments. Hydrogen diffusion had either prevented or at least masked the metallic transition.

Find out more

Metallic properties of elements:

http://chemistry.about.com/od/periodicitytrends/a/Metallic-Character.htm

Interiors of gas giant planets:

http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=166