PRESS RELEASE
8 February 2011

Icy Giants' Composition Re-examined

Molecular analysis of interior challenges current theories

(Trieste, Italy) A molecular simulation by ICTP researchers of a mixture of substances believed to compose the interior of the icy giant planets Neptune and Uranus has shown surprising properties that could help explain the unusual shape of the planets' magnetic fields. Results of the study, titled "Mixtures of planetary ices at extreme conditions" (DOI number 10.1038/ncomms1184) appear in the 8 February issue of Nature Communications.

Studies and simulations of the planets' interiors have so far been limited to the individual components of the planetary icy fluid, namely water, methane and ammonia. But in this new study, ICTP condensed matter researchers Sandro Scandolo and Mal-Soon Lee, who was a post-doctoral fellow at the Centre, focussed on properties of a methane-water mixture—believed to make up more than 90% of the middle layers of Neptune and Uranus—under simulated extreme temperature and pressure conditions. The molecular dynamic simulations they conducted showed that the properties of the mixture differ qualitatively from properties of the mixture's individual components under the same conditions.

After testing the mixture under four different pressure and temperature conditions, the researchers found that the mixture became an electronic conductor already at a pressure of 120 gigapascal, reflecting a remarkable change by methane and water as a mixture under extreme conditions, as compared to pure substances, which become metallic only above 600 gigapascal.

"This implies that the magnetic field (which in planets is generated through a "dynamo" mechanism by an electronic conductor) is generated in icy planets at shallower depths, and explains the unconventional shape of the magnetic field measured at Neptune and Uranus, though not its orientation," said Scandolo.

Pure methane is known to dissociate at extreme conditions, forming more complex hydrocarbons, diamond and fluid hydrogen. Accordingly, planetary models were revised to take into account the possible precipitation of diamond into the planetary cores. "We now show that when methane is mixed with water, at extreme conditions, it dissociates but carbon atoms do not form other species nor do they precipitate to form diamond," explained Scandolo.

He added that the finding that methane likes to mix with water at extreme conditions challenges the conventional picture (based on experience at ambient conditions) that methane is a "hydrophobic" species, i.e. it is not soluble in water at ambient conditions.

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About ICTP:

Based in Trieste, Italy, the Abdus Salam International Centre for Theoretical Physics fosters advanced studies and research in physics and mathematics, especially in developing countries. The Centre operates under a tripartite agreement between the Italian Government, UNESCO and IAEA. Each year about 7000 scientists from around the world visit ICTP for workshops, training and research. For more information, visit the website at http://www.ictp.it.

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