La prise de notes en conférence

Culture scientifique en L3

Institut Villebon-Charpak, Julien Bobroff

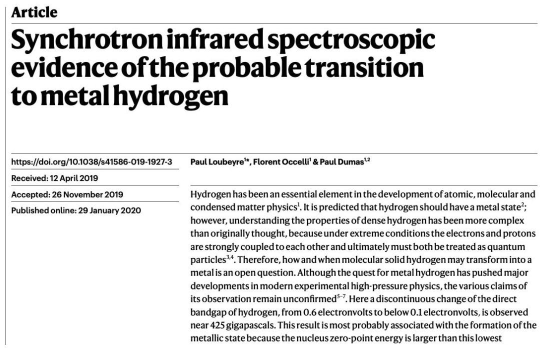
Quoi noter et comment pendant une conférence scientifique ?

la prise de notes

un exemple

comment créer une forte pression ?

en utilisant une enclume diamant



Article

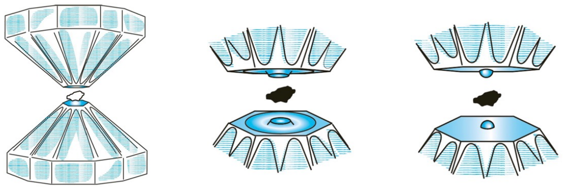
Synchrotron infrared spectroscopic evidence of the probable transition to metal hydrogen

https://doi.org/10.1038/s41586-019-1927-3
Received: 12 April 2019
Accepted: 26 November 2019
Published online: 29 January 2020

Paul Loubeyre[1]*, Florent Occelli[1] & Paul Dumas[1,2]

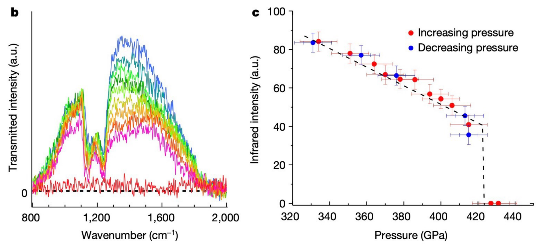
Hydrogen has been an essential element in the development of atomic, molecular and condensed matter physics[1]. It is predicted that hydrogen should have a metal state[2]; however, understanding the properties of dense hydrogen has been more complex than originally thought, because under extreme conditions the electrons and protons are strongly coupled to each other and ultimately must both be treated as quantum particles[3,4]. Therefore, how and when molecular solid hydrogen may transform into a metal is an open question. Although the quest for metal hydrogen has pushed major developments in modern experimental high-pressure physics, the various claims of its observation remain unconfirmed[5–7]. Here a discontinuous change of the direct bandgap of hydrogen, from 0.6 electronvolts to below 0.1 electronvolts, is observed near 425 gigapascals. This result is most probably associated with the formation of the metallic state because the nucleus zero-point energy is larger than this lowest

Les enclumes diamant



enclume simple	enclume taillée en torroïode	double enclume avec demi-sphères
jusqu'à 10^6 Bar	jusqu'à 5.10^6 Bar	jusqu'à 9.10^6 Bar

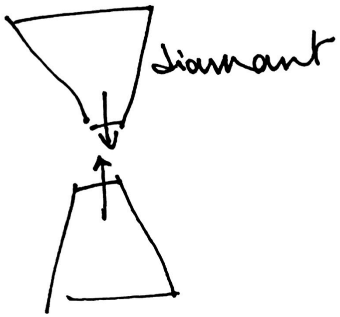
mesures avec de l'hydrogène gazeux



obtention d'hydrogène métallique
au dessus de 4,2 millions de Bar à T=80K

notez les idées et les chiffres clé (ne pas rédiger des phrases entières)

Pour ↗ P: enclumes diamant

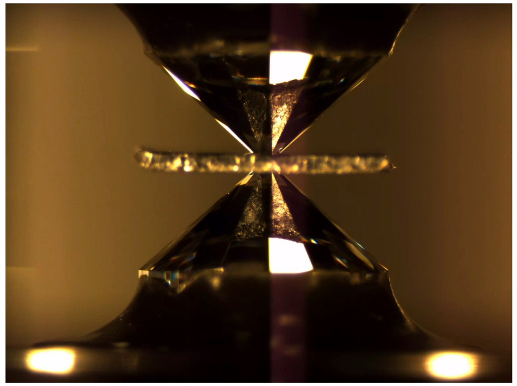


Pour ↗↗↗ P: demi-sphère en +
↳ jq 10^7 Bar

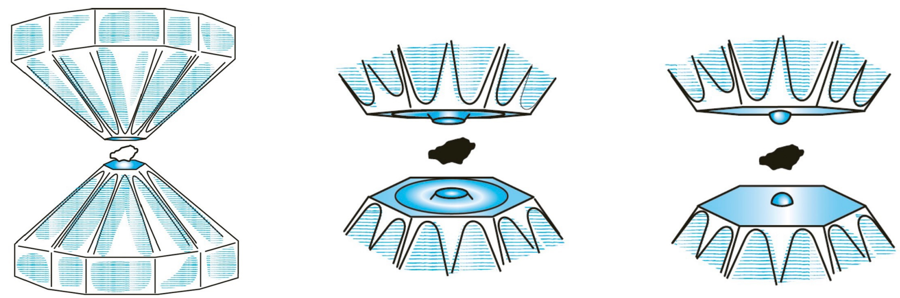
torroïde: jq 5.10^6 Bar

comment créer une forte pression ?

en utilisant une enclume diamant



Les enclumes diamant



enclume simple	enclume taillée en torroïode	double enclume avec demi-sphères
jusqu'à 10^6 Bar	jusqu'à 5.10^6 Bar	jusqu'à 9.10^6 Bar

repérer les refs biblios
(auteur, journal, année)

Loubeyre Nature 2000

Article

Synchrotron infrared spectroscopic evidence of the probable transition to metal hydrogen

https://doi.org/10.1038/s41586-01[illegible]7-3

Received: 12 April 2019

Accepted: 26 November 2019

Published online: 29 January 2020

Paul Loubeyre[1*], Florent [illegible]lli[1] & Paul Dumas[1,2]

Hydrogen has been a[illegible]ntial element in the development of atomic, molecular and [illegible]ics[1]. It is predicted that hydrogen should have a metal state[2]; [illegible]anding the properties of dense hydrogen has been more complex than originally thought, because under extreme conditions the electrons and protons are strongly coupled to each other and ultimately must both be treated as quantum particles[3,4]. Therefore, how and when molecular solid hydrogen may transform into a metal is an open question. Although the quest for metal hydrogen has pushed major developments in modern experimental high-pressure physics, the various claims of its observation remain unconfirmed[5–7]. Here a discontinuous change of the direct bandgap of hydrogen, from 0.6 electronvolts to below 0.1 electronvolts, is observed near 425 gigapascals. This result is most probably associated with the formation of the metallic state because the nucleus zero-point energy is larger than this lowest bandgap value. Pressures above 400 gigapascals are achieved with the recently developed toroidal diamond anvil cell[8], and the structural changes and electronic properties of dense solid hydrogen at 80 kelvin are probed using synchrotron infrared absorption spectroscopy. The continuous downward shifts of the vibron wavenumber and the direct bandgap with increased pressure point to the stability of phase-III hydrogen up to 425 gigapascals. The present data suggest that metallization of hydrogen proceeds within the molecular solid, in good agreement with previous calculations that capture many-body electronic correlations[9].

The search for metal hydrogen has a unique place in high-pressure physics. Indisputably, metal hydrogen should exist. Owing to increase in electron kinetic energy because of quantum confinement, pressure should turn any insulator into a metal, as observed for molecular oxygen around 100 GPa some 20 years ago[10]. At first, the prediction of the insulator–metal transition in dense hydrogen was intertwined with the molecular dissociation[2]. However, it was later suggested that metal hydrogen may exist as a proton-paired metal[11]. Quantitative predictions of the stability domain and of the properties of metal hydrogen remain challenging because many contributions could be in effect and should be self-consistently treated[3,4]; for example, many-body electronic correlations, nuclear quantum effects, nuclear spin ordering, coupling between protons and electrons (as suggested by a large Born–Oppenheimer separation parameter), or anharmonic effects. The most advanced calculations, such as diffusion Monte Carlo (DMC) simulations[4,9,12], now go beyond the electronic correlation mean-field description of density functional theory and try to capture many-body electronic correlations. Importantly, metal hydrogen should exhibit notable properties, such as room-temperature superconductivity[13–15], a melting transition at a very low temperature into a superconducting superfluid state[16] and a mobile solid state[17].

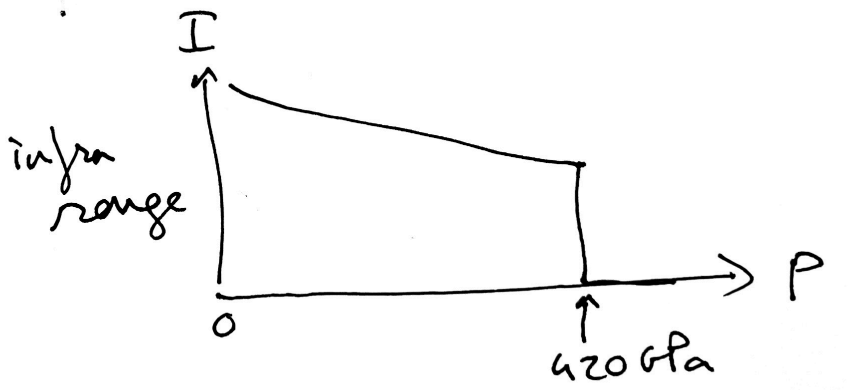
The change in the direct bandgap of solid hydrogen was previously measured up to 300 GPa by visible absorption measurements[18]. By extrapolating to zero the linear decrease of the bandgap with density, the transition to metal hydrogen was predicted to occur around 450 GPa. In this work, we extend the investigation of the direct bandgap decrease down to the near-to-mid-infrared energy range. Infrared measurements provide a non-intrusive method both to disclose structural changes and also to characterize the electronic properties of hydrogen up to its metal transition. Our approach is based on two experimental developments. First, in order to overcome the 400 GPa limit of conventional diamond anvil cells[19], we used the recently developed toroidal diamond anvil cell (T-DAC)[8] that can achieve pressures of up to 600 GPa. Importantly, under extreme pressures, the T-DAC preserves the advantages of the standard diamond anvil cell in terms of stress distribution, optical access and sample size. Synthetic type-IIa diamond anvils were used to provide infrared transparency down to 800 cm^{-1}. Second, an infrared horizontal microscope was designed to be coupled to a collimated exit port of a synchrotron-feed Fourier-transform infrared spectrometer at the SMIS beamline at the SOLEIL synchrotron facility. Such a high-brightness broadband infrared source is essential for measuring, by transmission, satisfactory signal-to-noise

[1]CEA, DAM, DIF, Arpajon, France. [2]Synchrotron SOLEIL, Gif-sur-Yvette, France. *e-mail: paul.loubeyre@cea.fr

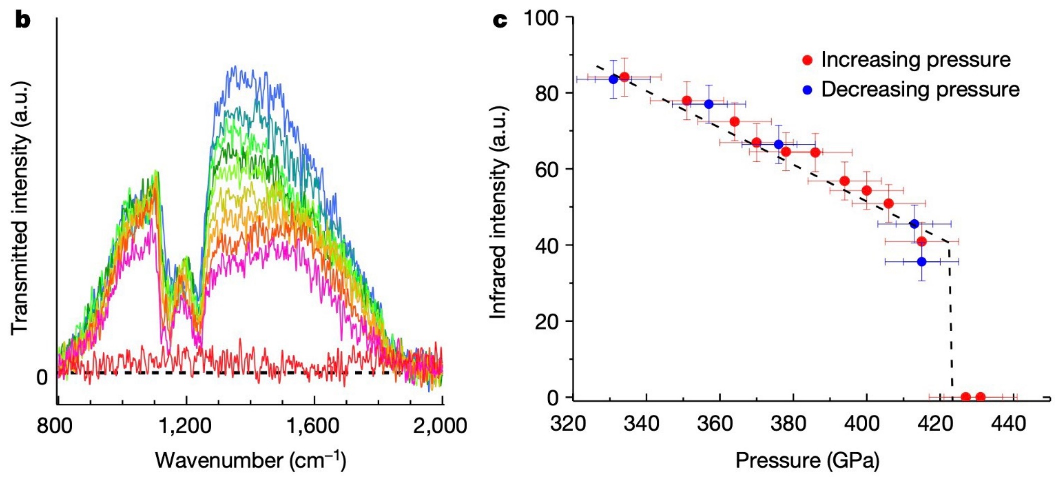
notez le résultat clé
de l'article

↳ P sur gaz H_2
↓
devient métal
à 420 GPa

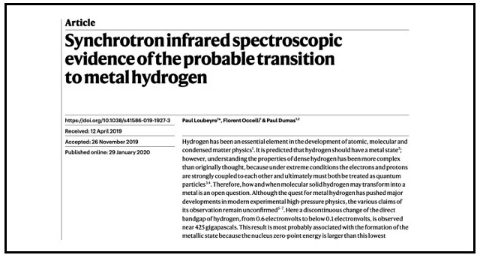
copiez la figure si besoin



mesures avec de l'hydrogène gazeux



obtention d'hydrogène métallique
au dessus de 4,2 millions de Bar à T=80K



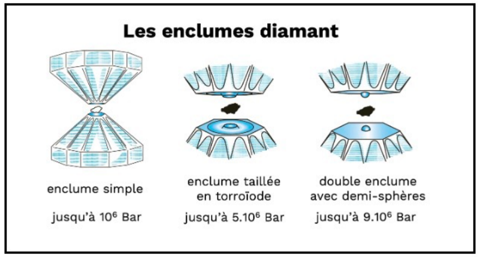
Article

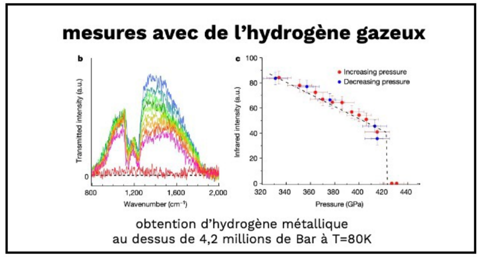
Synchrotron infrared spectroscopic evidence of the probable transition to metal hydrogen

https://doi.org/10.1038/s41586-019-1927-3
Received: 12 April 2019
Accepted: 26 November 2019
Published online: 29 January 2020

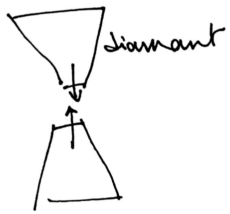
Paul Loubeyre[1]*, Florent Occelli[1] & Paul Dumas[1,2]

Hydrogen has been an essential element in the development of atomic, molecular and condensed matter physics[1]. It is predicted that hydrogen should have a metal state[2]; however, understanding the properties of dense hydrogen has been more complex than originally thought, because under extreme conditions the electrons and protons are strongly coupled to each other and ultimately must both be treated as quantum particles[3,4]. Therefore, how and when molecular solid hydrogen may transform into a metal is an open question. Although the quest for metal hydrogen has pushed major developments in modern experimental high-pressure physics, the various claims of its observation remain unconfirmed[5-7]. Here a discontinuous change of the direct bandgap of hydrogen, from 0.6 electronvolts to below 0.1 electronvolts, is observed near 425 gigapascals. This result is most probably associated with the formation of the metallic state because the nucleus zero-point energy is larger than this lowest





Pour ↗ P : enclumes diamant



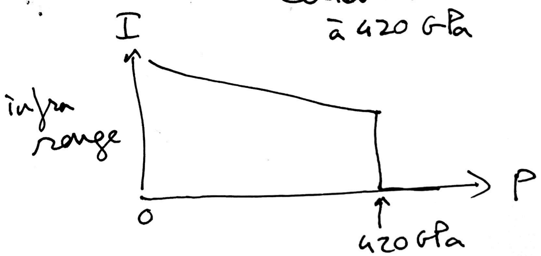
Pour ↗↗↗ P : demi-sphère en +

↳ jq 10^7 Bar

torroïde : jq 5.10^6 Bar

Loubeyre Nature 2000

↳ P sur gaz H_2
↓
devient métal à 420 GPa



La prise de notes en conférence

1. repérer les idées clé
2. repérer les résultats *quantitatifs*
3. recopier si besoin formules ou figures
4. repérer les sources biblios
   (nom d'auteur, année, revue)