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Multi-MBar studies of Oxygen and Hydrogen

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The study of simple archetypal molecular systems having an electronic structure heavily altered by ultra-high compression holds the promise of major breakthroughs in our understanding of matter. Among these systems, oxygen and deuterium are of particular interest due to their abundance in the Universe. We have used optical and synchrotron x-ray diffraction techniques to probe O_2 and H_2 (D_2) to above 300 GPa. Our study on dense oxygen more than doubles the pressure range at which it had been investigated before; the picture we observe is quite different from what was experimentally reported and predicted by theory. Our experiments on dense hydrogen (deuterium) reveal the appearance of a new semiconducting phase at above 220 GPa which persists up to 320 GPa - the highest pressure reached in our studies. This phase is characterized by emergence of intense, well defined low frequency Raman bands, together with the unprecedented softening of the vibron, ν_1, and appearance of a secondary vibron, ν_2 and slowly closing band-gap. Analysis of the Raman spectra suggests a peculiar graphene-like structure consisting of both atomic and molecular layers. For both systems we will discuss the differences in results and interpretations which currently present in the literature.