On the Lifetime of Metastable Metallic Hydrogen

L. B. Dubovskii and S. N. Burmistrov

Kuchatov Institute, Moscow, Russia

In connection with the recent experiments[1] we analyze stability of metallic hydrogen against nucleation of the stable molecular phase below the transition pressure P_c ~300 – 500 Gpa. The nucleation dynamics is governed by the tunneling of a critical molecular nucleus through a potential barrier in the low temperature region and by the thermal activation mechanism at high temperatures. In a wide region of pressures below the transition pressure $0.1P_c < P < P_c$ the critical nucleus of the molecular phase contains a large number of particles and has a large critical radius as compared with the interatomic spacing. The main reason for the large critical nucleus lies in the impossibilty to form a bound state of two hydrogen atoms, i.e. molecule, under high extrinsic electron density of the metallic phase at about r_s ~1.7. This results in the necessity of a density fluctuation yielding a void inside the metallic phase with the low electron density in the center so that the formation of molecules would become energetically favorable. The nucleation dynamics of molecular nuclei both at low and high temperatures can be described within the framework of the macroscopic approach. Within the above-mentioned $0.1P_c < P < P_c$ pressure region the lifetime of the metallic hydrogen phase proves to be practically infinite. In the low pressure region $P < 0.1P_c$ the formation of a void in the metallic state cannot be suppressed with the applied external pressure and the critical nucleus amounts to a few particles or less as the external pressure vanishes. Thus, we expect the opposite behavior with too small lifetime of the metastable metallic state, resulting in practically instant decay of the metallic hydrogen at low pressures.

1. M.I. Eremets and I. A. Trojan, Nature Materials **10, 927 (2011).**

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