On the transition of expanded fluid iron into a nonmetallic state

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At pressures $P = 30 - 100$ kbar and temperatures $T \sim 1$ eV a transition of fluid iron into a nonmetallic state has been detected. The result has been obtained by direct measurements of the dependence of the electric resistivity on internal energy and volume using the experimental technique [1]. The measurements have been carried out under the pressures which are much higher than the estimated liquid-vapor critical point pressure and in the specific volume range from the melting line to a value that is about 6 times larger than the specific volume in the normal solid state $V_0$. It is demonstrated that fluid iron remains a metal up to an expansion $V/V_0 \approx 3.3$, at which its resistivity reaches $4 \mu\Omega\cdot\text{m}$ and practically doesn’t depend on temperature. According to our estimates, in this state the mean free path length of the conducting electrons decreases to a value close to the interion separation. At $V/V_0 \geq 4.5$ fluid iron becomes a nonmetal for which the temperature coefficient of the electrical resistivity is negative and much larger in the absolute value than that in the metallic state.

The distinctive feature of the metal-nonmetal transition observed here compared to those in mercury and the alkali metals is the fact that the transition takes place in a transition metal and at a much higher temperature. The results reported here are presented in details in Ref. 2.