Magnetism of impurities in 3D topological semimetal α-Cd_3As_2

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The electron spin resonance (ESR) for Eu^{2+}, magnetic and conductive properties of the 3D Dirac topological semimetal α-Cd_3As_2 doped with a small amount of europium impurity was first studied. At present, it has been established that α-Cd_3As_2 is a topological semimetal, a 3D analog of graphene. The conduction band and the valence band of the α-Cd_3As_2 have linear dispersion law and touch each other in the 3D Brillouin zone in Dirac nodes. In the presence of time reversibility and inversion symmetry, the Dirac nodes are twice degenerate. The break of any symmetry leads to the splitting of the Dirac node into two Weyl nodes, separated either by the energy interval (see the right insert in the figure) or separated in momentum space. Thus, the presence of a magnetic field or magnetic impurities in the Dirac semimetal (DSM) transforms it into a Weyl semimetal (WSM) and leads to a number of unusual phenomena. Here we assume that we have discovered an unusual type of diamagnetically ordering of magnetic impurity. Data on the magnetic susceptibility (see figure) and ESR showed the presence of an Eu^{2+} ions additional phase magnetized oppositely to the external field and ordered at T_{AFM} ~ 124 K. Measurements of ESR, carried out at high temperatures, allow us to conclude that this phase (g- factor is near 4.4) consists of the Eu^{2+} ions located in interstices positions - tetrahedral vacancies in fluorite type cell (see left insert in figure). Whereas the main phase (g ~ 2.2) consists of the Eu^{2+} ions in the positions substitution of the Cd^{2+} ions. These positions differ in the degree of chemical compression of the Eu^{2+} ions. Due to the proximity of the size of the Cd^{2+} ion to the size of the nonmagnetic Eu^{3+} ion, this leads to the fact that the magnetic moment of ions in the interstitial positions effectively decreases. About 10% of all Eu^{2+} ions places in this position. When doping in an amount of about 0.1 at. %Eu, the electron concentration increases from ne = $6 \bullet 10^{17}$ $см^{-3}$ for α-Cd_3As_2 to ne = $2{,}2 \bullet 10^{19}$ $см^{-3}$ for the doped sample and is temperature independent. The last value is more the Eu impurity content and this requires accurate consideration of question about distribution of the Eu between valence and conduction zones. The ESR data show anomalous large values of the g - factor of the Eu^{2+} ions, which in its turn indicates very large values of the g factor of the conduction electrons (g ~ 16-18). This indicates very interest interplay between Eu^{2+}, Eu^{3+} ions and their "free" electrons. We believe that selectively ordering of the Eu^{2+} ions located in tetrahedral vacancies oppositely to the external field is the result of the splitting of twice degenerate Dirac nodes on two Weyl nodes with different energies, on a similarity to splitting of electronic states with different spin directions.

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