Magnetic Polarons in Magnetic Semiconductors

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During the last 50 years the world has witnessed remarkable developments in the fields of electronics and information technologies. From the earliest transistor to the microprocessor in a modern computer, electronic devices have employed the transport of electric charges. In order to enhance the multi-functionality of devices (for example, carrying out processing and data storage within the same chip), researchers have tried to exploit another property of the electron — its spin — which can also carry information. However, the semiconductors currently used in integrated circuits, such as Si, Ge and GaAs, are non-magnetic, in which the carrier energy is almost independent of the spin direction. In contrast, in magnetic semiconductors (MS), which are examples of strongly correlated electron systems, the (super)exchange interaction gives rise to pronounced spin-related phenomena. Extensive studies of the MS in late 1960s and 1970s led to development of new concepts in condensed matter physics such as *magnetic polarons* and *magnetic phase separation*. The current renaissance of MS is caused by the fact that they are relatives to such materials as diluted magnetic semiconductors (DMS), high-temperature superconductors and colossal-magnetoresistance manganites [1].

Magnetic semiconductors are of fundamental interest because they provide optimal conditions for the formation of a new type of quasiparticle — conduction electrons "autolocalized" in an atomic-scale region of unstable phase which is stabilized by that localization (*e.g.*, as a FM droplet in an AFM sea).

Here we report results of the first systematic muon spin relaxation studies of magnetic semiconductors EuSe, EuTe, EuS, EuO, $CdCr_2Se_4$ and $HgCr_2Se_4$.. In all these materials electrons effectively localize around the muon with formation of magnetic polarons. Measurements of the hyperfine parameters allow determination of the characteristic electron localization lengths.

[1] E.L. Nagaev, *Colossal Magnetoresistance and Phase Separation in Magnetic Semiconductors* (London: Imperial College Press, 2002).