Time-domain synchrotron Mössbauer spectroscopy at extreme conditions

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Time-domain synchrotron Mössbauer spectroscopy (SMS) (aka. nuclear forward scattering) utilizes a synchrotron radiation source to excite the nuclei. The brilliant and focused synchrotron X-ray beam makes the technique compatible with complex sample environment such as high pressure and low temperature. After APS-U due to the change from 24- to 48-bunch timing mode, shorter lived isotopes are more favorable such as ^{151}Eu ($\tau_{1/2}$ = 9.7 ns) and ^{161}Dy ($\tau_{1/2}$ = 28.2 ns). In this talk I will discuss two case studies in $EuFeAs_2$ and Dy metal to investigate the magnetic phase diagram under high pressure and low temperature in diamond anvil cell.

Divalent Eu-based intermetallic compounds exhibit rich magnetic properties due to the strong local magnetic moment. In Eu-based pnictide superconductors, peculiar coexistence of two collective phenomena, magnetic order from Eu ions and bulk superconductivity from Fe-As layers, makes these systems ideal platforms to investigate the competition of magnetism and superconductivity. Aiming to establish the microscopic P-T phase diagram of recent 112-type iron-pnictides $EuFeAs_2$ high-pressure SMS experiments in ^{151}Eu and ^{57}Fe have been performed in the parent as well as Ni-doped compounds. We have found that application of pressure completely suppresses the itinerant electron magnetism from the Fe sublattice and the local magnetism in Eu ions. The suppression of local magnetism is associated with a significant increase of mean valence in Eu ions.

In the case of Dy metal, the local-moment magnetism has been studied under high pressure up to 141 GPa using SMS. With increasing pressure Dy's magnetic ordering temperature changes drastically. At 10 K the hyperfine magnetic field of Dy remains almost constant with increasing pressure up to 141 GPa, showing the robustness of the local magnetism. At about 120 GPa magnetic ordering temperature increases sharply to ~280 K and drops at higher pressure, in good agreement with the Doniach scenario.