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Effect of heavy-ion and electron irradiation on properties of Fe-based superconductors

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The introduction of defects by particle irradiation is used to reveal the role of disorder in matter, which is unavoidable in all crystalline solids. In superconductors defects introduce flux pinning, controlling critical current, J_c; as well as pair-breaking scattering, limiting the critical temperature, T_c. To elucidate defect related properties of Fe-based superconductors (FBS) we precede in two types of irradiation: heavy ion (6GeV Pb) to create disorder in the form of amorphous tracks and low temperature electron irradiation (2.5MeV at 20K) to create point like defects. Substantial increase of irreversible magnetization and an upward shift of the irreversibility line are observed after heavy ion irradiation of all FBS investigated to date. In $BaK122$, signatures of a Bose-glass vortex state; angular dependence and variable-range hopping flux creep are revealed. Remarkably, heavy ion irradiation does not depress T_c, however, point-like disorder introduced by electron irradiation does substantially. In isovalently substituted $Ba(FeAs_{1-x}P_x)_2$ and $Ba(Fe_{1-x}Ru_xAs)_2$ crystals, T_c decreases linearly with dose. Suppression to 40% of initial value of T_c was achieved in $Ba(FeAs_{1-x}P_x)_2$. An increase of normal state resistivity is observed and correlated to depression of T_c. Change of superconducting gap structure with disorder was determined from penetration depth measurements, $\lambda(T)$ dependence, at various stages of irradiation. Linear in T variation of pristine samples, indicative of the presence of nodes in gap, turned at low irradiation dose to exponential T variation, indicative of a fully gaped state. T^2 variation of λ is observed at higher doses. This behaviour is incompatible with symmetry-imposed nodes of d-wave pairing but consistent with $S+/-$, $S+/+$ mechanisms. This is the first observation of the impurity-induced node lifting expected in anisotropic s-wave superconductors