Josephson Effect through Metallofullerene Molecules

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We investigate the Josephson effect through a metallofullerene molecule with exchange coupling between spins of electrons in carbon shell and heavy rare-earth metal ion in it. By using the numerical normalization group method we calculate the Andreev level and the supercurrrent and examine interwined effect of the exchange coupling, Kondo correlation, and superconductivity on the current. Exchange coupling typically suppresses the Kondo correlation so that the system undergoes a phase transition from 0 to π-junction as $|J|$ increases, where J is the exchange coupling constant. The physical natures of the transition are different for opposite signs of J, and the phase boundaries are asymmetric with respect to the sign of J. In additions, ferromagnetic coupling much larger than the superconducting gap is observed to restore 0-junction. We suggest that the asymmetric dependence of supercurrent on J can be used as a good measure to detect the sign of J in experiment.