Isotope Effect in Rattling-Induced Superconductor

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Recently, superconductivity in β-pyrochlore oxides AOs_2O_6 (A = K, Rb, and Cs) have attracted much attention due to the relatively high superconducting transition temperature T_c. In these materials, an alkali atom in a cage composed of oxygen and osmium ions oscillates with large amplitude and such anharmonic oscillation is called *rattling*. When the alkali atom oscillates in the anharmonic potential with wide and flat bottom, it has been found that phonon eigenenergy is totally suppressed and the energy difference between adjacent eigenstates is decreased in the low-energy region. Then, even if the original electron-phonon coupling is weak, a strong-coupling situation is virtually realized due to the effect of anharmonicity, leading to the increase of T_c, in spite of the decrease of average phonon energy. In order to confirm the contribution of the rattling, we propose to examine isotope effect on T_c. In standard phonon-mediated superconductors, it has been well known that T_c is in proportion to $M^{-\alpha}$ with α=1/2, where M is the mass of oscillator. Note that the electron-phonon coupling does not depend on M for harmonic phonons. However, in the rattling-induced superconductor, the magnitude of α should be deviated from 1/2, since the electron-phonon coupling is effectively changed by anharmonicity, as mentioned above. In particular, we expect an interesting possibility of negative α, which suggests peculiar *inverse* isotope effect. In this presentation, we discuss the evidence of rattling-induced superconductivity from the calculated results on α within the framework of the Migdal-Eliashberg theory.