Evidence for the Existence of the $[2\,0\,2]3/2$ Deformed Band in Mirror Nuclei $^{25}$Mg and $^{25}$Al

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No.11 in “100 Papers Selection” (p.67)

After fifty years of its prediction, the highest-lying $[2\,0\,2]3/2$ orbit among the six Nilsson single-particle orbits originating from the sd shells in prolate deformed nuclei and the rotational band on this orbit were identified. This orbit lies at the Fermi level for nuclei with neutron number $N$ or proton number $Z$ approximately 19. Nilsson orbits are observed only in deformed nuclei. Therefore, the expectation was that this orbit would not be observed in nuclei near the stability line at low excitation energy, because nuclei with these $N$ or $Z$ are not deformed due to the shell closure at $Z$ and/or $N = 20$. However, this orbit can play an important role in nuclei away from the stability line, the study of which will be the main subject in the near future.

The $[2\,0\,2]3/2$ orbit and the band members were found in $^{25}$Al situated near the stability line but at high excitation energies of 6 - 7.5 MeV in a $^{25}$Mg($^3$He,$t$)$^{25}$Al charge-exchange measurement. Precise beam matching techniques among the Ring Cyclotron, WS beam line and the magnetic spectrometer Grand Raiden at the Research Center for Nuclear Physics were applied to this ($^3$He,$t$) measurement. One order of magnitude better energy resolution of $\Delta E = 30$ keV was realized than in pioneering ($p$, $n$) measurements. This world-record high energy-resolution made it possible to study in detail the nuclear structure at high excitation energies.

(1) Energy diagram of Nilsson orbits in the sd shell of atomic nuclei. Nuclei with $N$ or $Z$ of 8 or 20 are spherical, while nuclei are largely deformed in the middle of the sd shell.

(2) The beam from the Ring Cyclotron is shaped by the high-dispersive WS beam line so as to realize the “matching conditions” with the spectrometer. High energy-resolution and good angle resolution are realized.

(3) One order of magnitude better energy resolution of the ($^3$He,$t$) measurement compared to the pioneering ($p$, $n$) measurement brought a qualitative change in the energy spectra.

Enhancing the Superconducting Transition Temperature of the Heavy Fermion Compound CeIrIn$_5$ in the Absence of Spin Correlations

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No.14 in “100 Papers Selection” (p.67)

In this paper, we report on a pressure-induced evolution of superconductivity and spin correlations in heavy-fermion superconductor, CeIrIn$_5$, via the $^{115}$In nuclear-spin-lattice-relaxation rate measurements. We find that applying pressure suppresses dramatically the antiferromagnetic fluctuations that are strong at ambient pressure. At $P = 2.1$ GPa, $T_c$ increases to $T_c = 0.8$ K that is twice $T_c$ ($P = 0$ GPa), in the background of Fermi-liquid state. This is in sharp contrast with the previous case in which negative, chemical pressure (replacing Ir with Rh) enhances magnetic interaction and increases $T_c$. Our results suggest that multiple mechanisms work to produce superconductivity in the same compound CeIrIn$_5$.