(7c6)

^{101}Ru NQR and ^{29}Si NMR Studies of the Hidden Order in URu_2Si_2

S. Takagi[1], S. Saitoh[1], H. Sasaki[1], M. Yokoyama[2]and H. Amitsuka[3]

[1]Graduate School of Science, Tohoku University, Sendai 980-8578
[2]Faculty of Science, Ibaraki University, Mito 310-8512
[3]Graduate School of Science, Hokkaido University, Sapporo 060-0810

The U-based heavy-electron superconductor URu_2Si_2 with the tetragonal $ThCr_2Si_2$-type structure has continuously been a subject of intensive investigations in these two decades. In spite of growing consensus in these five years that the previously identified antiferromagnetic (AF) phase occurs only in a very tiny part of the sample under ambient P, the order parameter below the still unclarified phase transition at T_0=17.5 K in the remaining major part has never been identified clearly. Various models have been proposed to describe this hidden order (HO) phase. We have been investigating the HO by complementarily utilizing, under ambient P on a single crystal, ^{101}Ru (I=5/2) NQR under $H_{\rm ext}$=0 and ^{29}Si (I=1/2) NMR with both $H_{\rm ext}//a$-axis and $H_{\rm ext}//c$-axis.

We first show that U $5f$ quadrupoles can be probed through ^{101}Ru NQR. The observed T-dependence of the NQR frequency $^{101}\nu_{\rm 2Q}(T)$ can quite naturally be explained for $T > T_0$ in terms of the singlet ground-state model. Then, combining with general considerations on the effects of symmetry-breaking electric field gradient (EFG) or hyperfine field (HF) on ^{101}Ru NQR, we show that the observed slight, but significant increase of $^{101}\nu_{\rm 2Q}(T)$ below $T_{\rm Q}$ 13.5 K indicates the order of U $5f$ quadrupoles below this temperature. Quite remarkably, the onset of the increase of $^{101}\nu_{\rm 2Q}(T)$ and hence the quadrupole order is retarded by about 4 K below T_0. Finally, we present that ^{29}Si NMR under finite $H_{\rm ext}$ shows additional line-broadening $\Delta H_{\rm HO}$ below T_0, which strongly suggests the onset of octupole order below this temperature. Non-monotonous T- and $H_{\rm ext}$-dependences of $\Delta H_{\rm HO}$, however, suggest that the HO phase hides sub-phases, which is consistent with the results of ^{101}Ru NQR under $H_{\rm ext}$=0.