The mystery of $CeRhIn_5$ in high magnetic fields

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Antiferromagnetic $CeRhIn_5$, discovered some two decades ago, is now one of the best-studied Ce-based heavy-fermion compounds. Yet, it continues to attract a lot of attention of the scientific community due to its unique behaviour in high magnetic fields. When the magnetic field is applied along, or close to, the *c* axis, a new phase characterized by a pronounced in-plane electronic anisotropy emerges at $B^* \approx 30$ T, well below the critical field, $B_c \simeq 50$ T, to suppress the antiferromagnetic order. The exact origin of this new phase, originally suggested to be either a density-wave phase [1] or an electronic-nematic state [2], remains elusive. It was further suggested that a field-induced Fermi-surface reconstruction corresponding to the delocalization of the *f* electrons occurs at B^* [3].

In my talk, I will present our recent results of the high-field de Haas-van Alphen (dHvA) effect, specific-heat, ultrasound-velocity, and NMR measurements in $CeRhIn_5$. Our comprehensive dHvA measurements in fields up to 70 T unambiguously suggest that the Ce 4*f* electrons in $CeRhIn_5$ remain localized over the whole field range. This rules out any Fermi-surface reconstruction, either at the suggested nematic phase transition at $B^* \approx 30$ T or at the putative quantum critical point at $B_c \simeq 50$ T [4]. Our specific-heat measurements in fields applied along the c axis revealed a small but distinct anomaly at B^*, which we discuss in terms of a field-induced transition, probably weakly first-order. We further suggest that the transition corresponds to a change of magnetic structure [5]. This hypothesis is supported by our ultrasound velocity [6] and NMR measurements performed in magnetic fields slightly tilted from the c axis

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