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# Nematic Electronic State and Magnetoelastic Quantum Oscillations in $CeRhIn_5$

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## Introduction

$CeRhIn_5$ crystallizes in the quasi-two-dimensional tetragonal structure and displays antiferromagnetic (AF) ordering at $T_N \approx 3.8$ K. The evolution of the ground states as a function of applied pressure, including a pressure-induced superconducting transition at 2.1 K, is prototypical of heavy-fermion superconductors and its high Tc is attributed to the quasi-2D crystal structure [1]. Quantum oscillations in the magnetization [1] and transport [2], observed for H//[100] and H//[001] at $T < T_N$ in magnetic fields to 50T, reveal additional details including an anisotropic Fermi surface and an apparent phase transition to an electronic nematic state of matter at $H^* \approx 30$T [2,3].

## Experimental

Fiber Bragg grating (FBG) magneto-strain experiments [4] were carried on *c*-axis oriented single crystals of $CeRhIn_5$, in 35T DC and 45T hybrid magnets at the NHMFL DC field facility, in the temperature range 0.35 K to 40 K.

## Results and Discussion

We measured the low temperature thermal expansion and magnetostriction of $CeRhIn_5$ to magnetic fields exceeding 40T. The axial and transverse magnetostriction, after subtraction of a smooth quadratic in field background, show clear anomalies near 28T (Fig1.). Magnetostriction quantum oscillations confirm a Fermi surface change at H* with the emergence of new orbits. By analyzing the field-induced change in the crystal-field ground state, we conclude that the in-plane Ceb4f hybridization is enhanced at H*, in agreement with the in-plane lattice expansion. We argue that the nematic behavior observed in this prototypical heavy-fermion material is of electronic origin, and is driven by the hybridization between 4f and conduction electrons which carries the f-electron anisotropy to the Fermi surface.

## Acknowledgements

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## References

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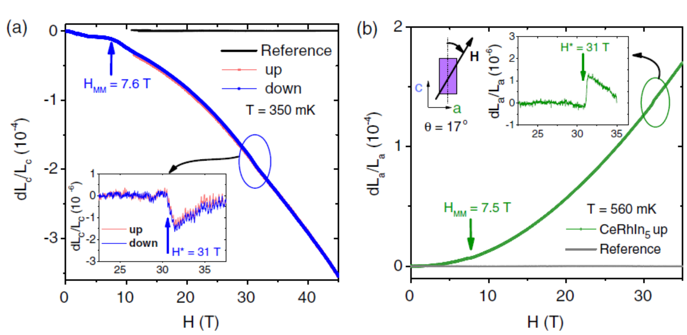


**Fig.1** Magnetostriction of $CeRhIn_5$ along (a) the c-axis at T = 0.35 K and (b) the a axis at T = 0.56 K for fields applied ≃20° off the c-axis. Here θ is the polar angle between the applied field and the c-axis. The azimuthal angle is set to ϕ = 90°. Insets show the data after a background subtraction.

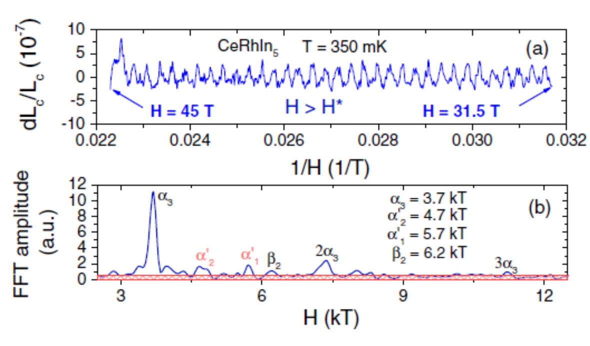


**Fig.2** (a) Magnetostriction of $CeRhIn_5$ at 350 mK as a function of inverse field for fields applied ≃20° off the c axis. A high-pass filter was used to remove low-frequency oscillations that likely originate from the background difference below and above H*. (b) FFT spectra in the region 31.5 < H < 45 T. The dashed area is an estimate of the noise floor.