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New High Field Superconducting Phase in $CeCoIn_5$

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We have measured ultrasound velocity of the unconventional superconductor $CeCoIn_5$ which has extremely large Pauli paramagnetic susceptibility. Very recent reports of heat capacity measurements in field parallel to the *ab*–plane of $CeCoIn_5$ [1] have raised great interest, because they possibly point to the occurence of a Fulde-Ferrel-Larkin-Ovchinikov (FFLO) phase [2].

Sound velocities of the transverse mode with propagation $\mathbf{k} \parallel [100]$ ([010]) and polarization $\mathbf{u} \parallel [010]$ ([100]) were measured in the magnetic field $\mathbf{H} \parallel [100]$. Figure 1 shows temperature dependence of the sound velocity v_t^0 in (a) $\mathbf{H} \perp \mathbf{u}$, and (b) $\mathbf{H} \parallel \mathbf{u}$. The sound velocity is strongly enhanced when it tilts the flux line lattice (FLL) from the field direction ($\mathbf{H} \perp \mathbf{u}$), indicating the strong coupling between FLL and crystal lattice.

Our experimental results reveal an unusual structural transformation of the FLL in the vicinity of the upper critical field. These results provide a strong evidence that the high field state is the textured order parameter state, i.e. the FFLO phase, in which the order parameter is spatially modulated and has planar nodes aligned perpendicular to the vortices.

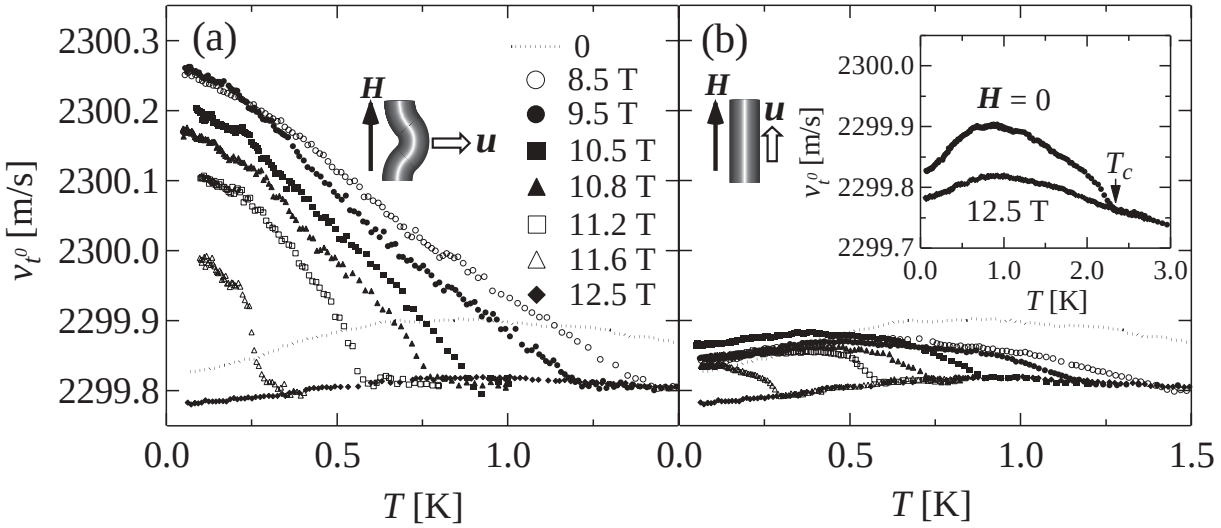

Figure 1: Temperature dependence of the transverse sound velocity v_t^0 in (a) $\mathbf{H} \perp \mathbf{u}$, and (b) $\mathbf{H} \parallel \mathbf{u}$. Inset in (b) shows the sound velocity in zero field and normal state above H_{c2}.

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