(ps46)

A change of the $4f$-electron character from localized to itinerant at critical pressure in $CeRhIn_5$

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We carried out the de Haas-van Alphen (dHvA) experiment for an antiferromagnet $CeRhIn_5$ at high pressures up to 3 GPa. Figures 1 (a) and (b) show the pressure dependence of the dHvA frequency and the cyclotron mass, respectively. The cross-sectional area of the Fermi surfaces due to main dHvA branches α_i and β_2 in $CeRhIn_5$ at ambient pressure, which are well explained by two kinds of nearly cylindrical Fermi surfaces of a non-$4f$ reference compound $LaRhIn_5$, are unchanged up to about 2.3 GPa, but the corresponding cyclotron masses increase steeply above $P^* = 1.6$ GPa where pressure-induced superconductivity sets in : $5.5\,m_0$ at ambient pressure, $20\,m_0$ at 1.6 GPa and $60\,m_0$ at 2.1 GPa for branch β_2, for example. Above 2.4 GPa, new dHvA branches appear, which are in good agreement with the corresponding dHvA branches of a $4f$-itinerant heavy fermion superconductor $CeCoIn_5$, indicating that the $4f$ electron becomes itinerant and significantly contributes to the volume of the Fermi surface. And the cyclotron mass of the new branch α_3, which was observed above 2.4 GPa, decreases slightly with increasing pressure : about $30\,m_0$ at 2.4 GPa and $24\,m_0$ at 2.9 GPa.

The $4f$ electron is thus changed from localized to itinerant at a critical pressure $P_c \simeq 2.35$ GPa where the superconducting transition temperature becomes a maximum. Nevertheless superconductivity is observed in both the pressure regions ranging from 1.6 to 5.2 GPa. Pressure-induced superconductivity is not related to the topology of the Fermi surface, but to the heavy fermion state, although the Fermi surface is very similar between $P < P_c$ and $P > P_c$.

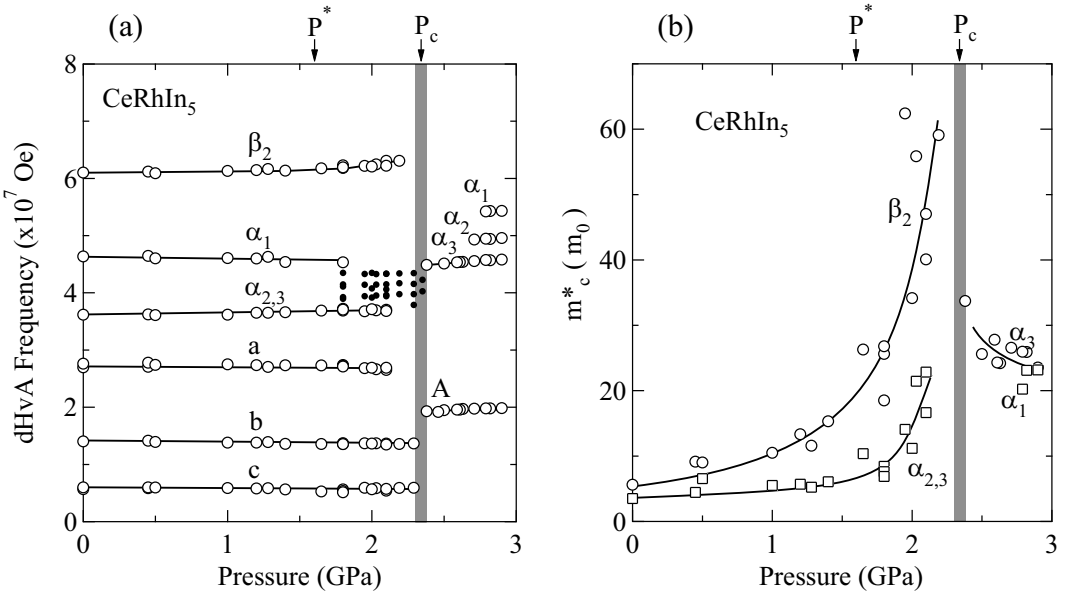

Figure 1: (a) Pressure dependence of the dHvA frequency in $CeRhIn_5$ and (b) Pressure dependence of the cyclotron mass in $CeRhIn_5$.