Heavy Fermion Materials

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Solid State, 9/20/2017

Outline

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- A heavy fermion material is a material with highly correlated electrons
- Kondo effect,

$$\rho(T) = \rho_o + aT^2 + c_m \ln \frac{\mu}{T} + bT^5 \tag{1}$$

Outline

- Despite being highly correlated, these materials can be described as a fermi liquid.
- Specific Heat

$$C_p = \frac{\pi^2}{2}\frac{k_B}{\epsilon_f} n k_b T \tag{2}$$

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$$\epsilon_f = \frac{\hbar^2 k_f^2}{2m^*} \tag{3}$$

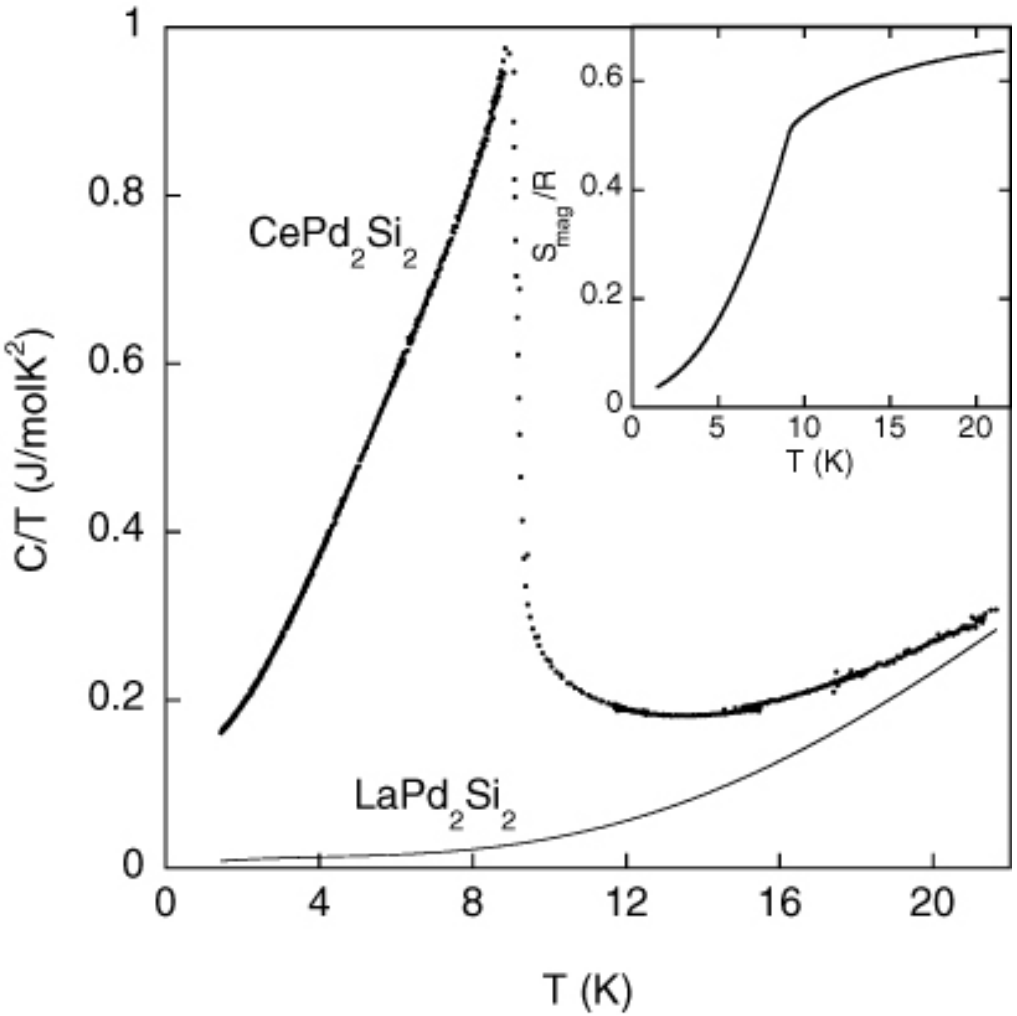


Figure: I. Sheikin, Y. Wang, F. Bouquet, P. Lejay, and A. Junod, Journal of Physics: Condensed Matter, Volume 14, Number 28

Outline

- Kondo Insulator, above a certain temperature, the material is metallic and below a certain temperature it becomes insulating.

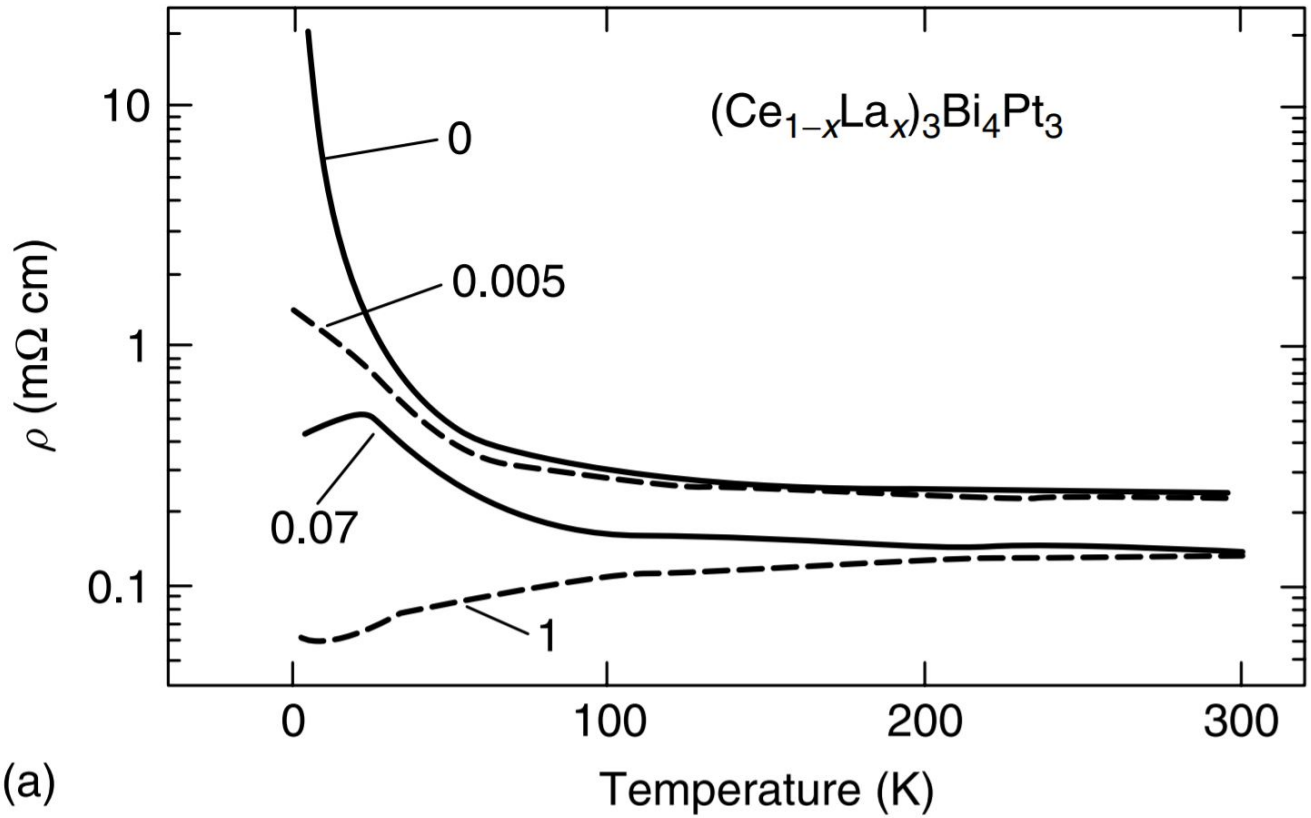


Figure: "Heavy Fermions: Electrons at the Edge of Magnetism" Piers Coleman

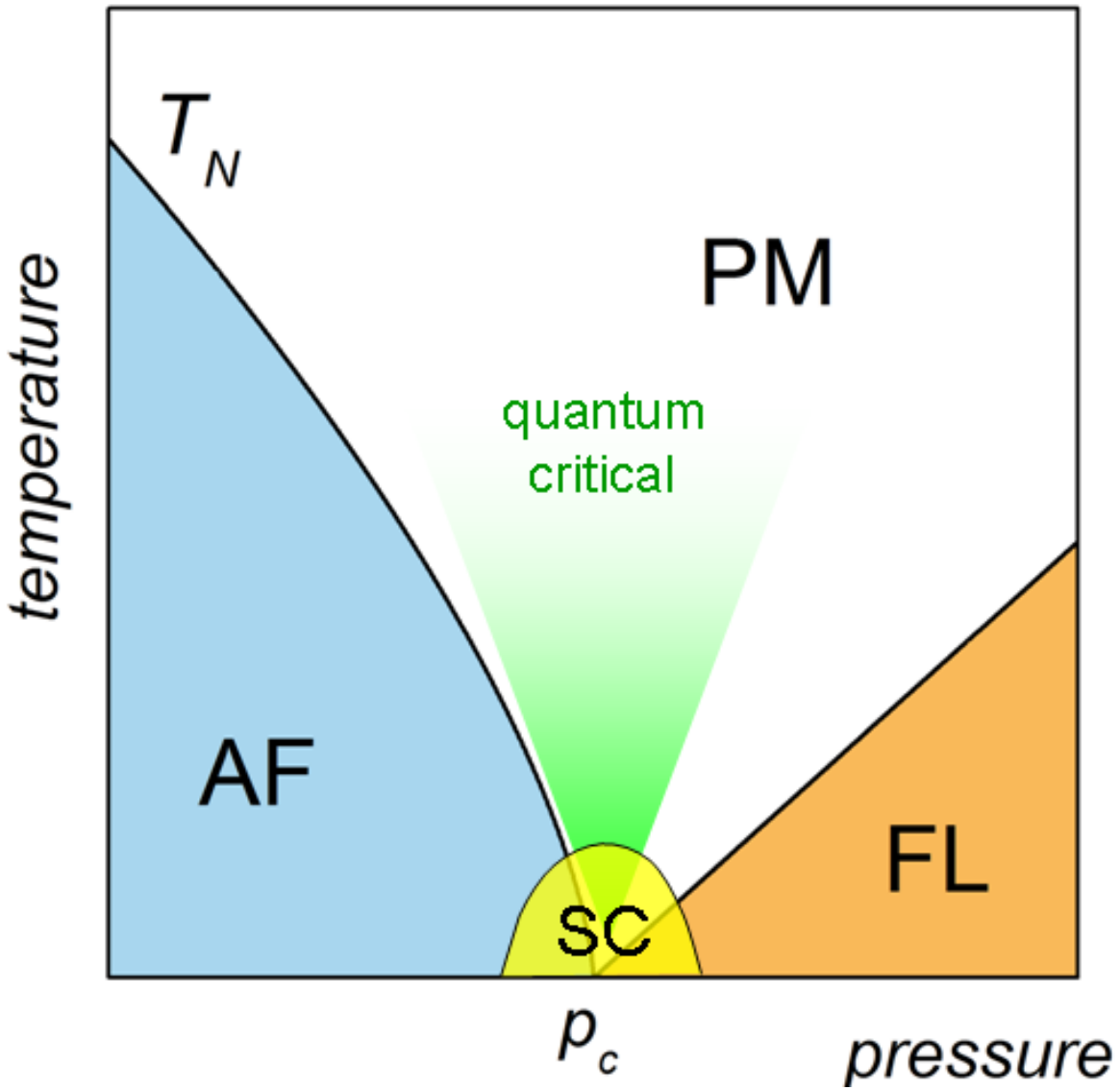
Outline

- Normal BCS superconductors form cooper pairs by interacting with the lattice. ie via phonons.
- So metals that have strong interaction with the lattice usually make good superconductors.

- But heavy fermionic materials are too "heavy" to interact with the lattice. Yet we have found at least 30 heavy fermion superconductors.

Outline

- Some heavy fermion materials contain quantum critical points. Example: Antiferromagnetic.


T_N
PM
quantum
critical
AF
FL
SC
temperature
p_c
pressure

Summary

- Heavy fermions are highly correlated electron systems.
- They follow simple fermi liquid laws which appear to make them heavier.
- They exhibit a barrage of interesting properties that we still don't fully understand.