# Superfluid Density in Heavy Fermion Superconductors $Ce_{1-x}Yb_xCoIn_5$

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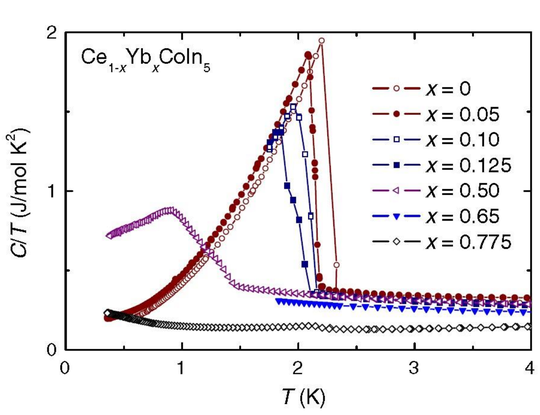
## Motivation

1.$CeCoIn_5$: unconventional HF superconductor; NFL behavior; magnetic feild-induced QCP.

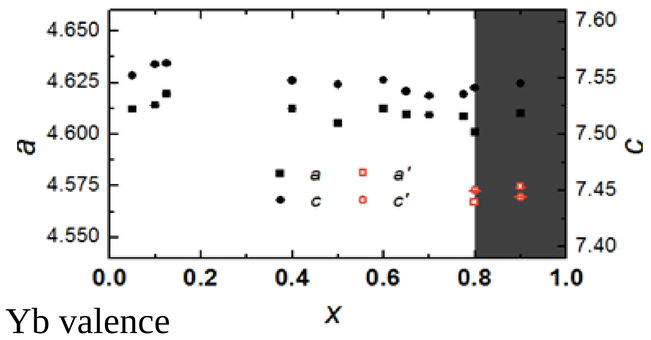
2.$YbCoIn_5$: conventional nonmagnetic metal (1K ~ 300K)

3. Interesting $Ce_{1-x}Yb_xCoIn_5$ system:

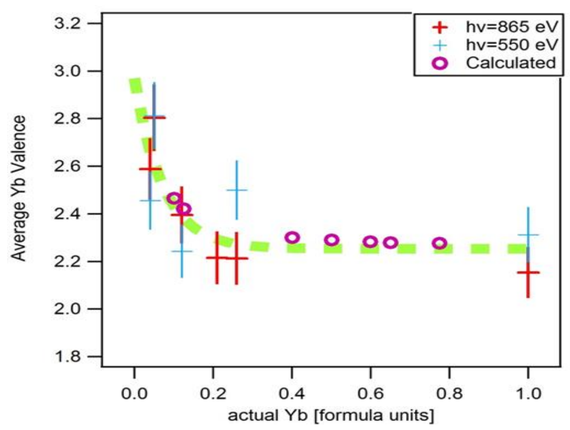
Heat capacity




## Crystal lattice constants

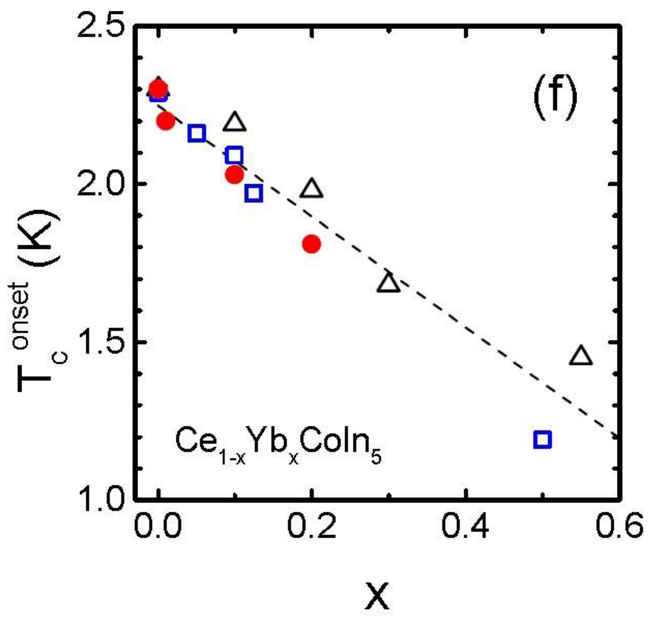



Yb valence




Shu *et. al*. 2011

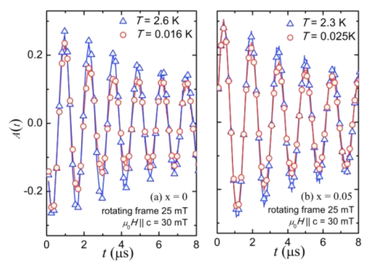
## Linear doping dependence of $T_c$ of $Ce_{1-x}Yb_xCoIn_5$




linear doping dependence of $T_c$ (red solid dots datas :H.Kim et al.2014 ,blue squares: Capan et al. 2010 and black triangles: Shu et al. 2011)

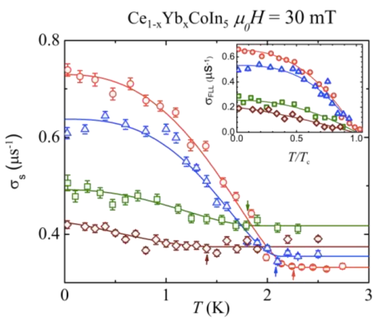
## MuSR data

Asymmetry spectra of $Ce_{1-x}Yb_xCoIn_5$




$$A(t) = A_0[f_s \exp(-\frac{1}{2}\sigma_s^2 t^2)\cos(\omega_s t + \phi)$$
$$+(1-f_s)\exp(-\frac{1}{2}\sigma_b^2 t^2)\cos(\omega_b t + \phi)]$$

*T* dependence of the muon relaxation rate

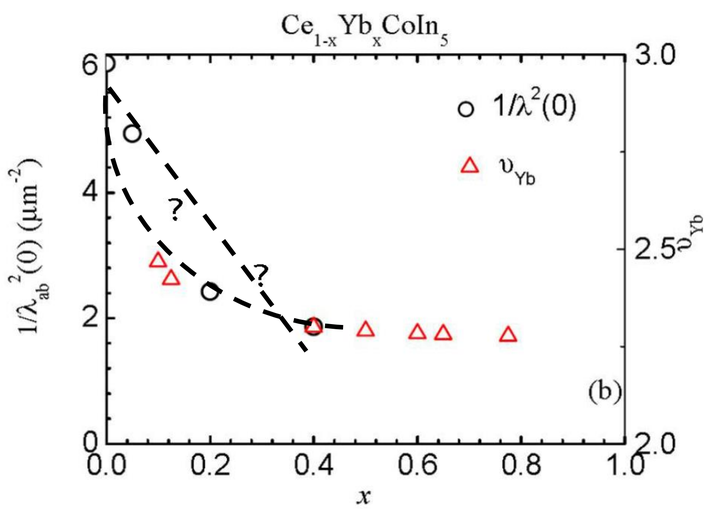



$$\sigma_s(T) = \sigma_s(0)(1-(T/T_c)^n)$$

$$2\sigma^2/\gamma_\mu = 0.00371\Phi_0^2\lambda^{-4}$$

E. H. Brandt 1988

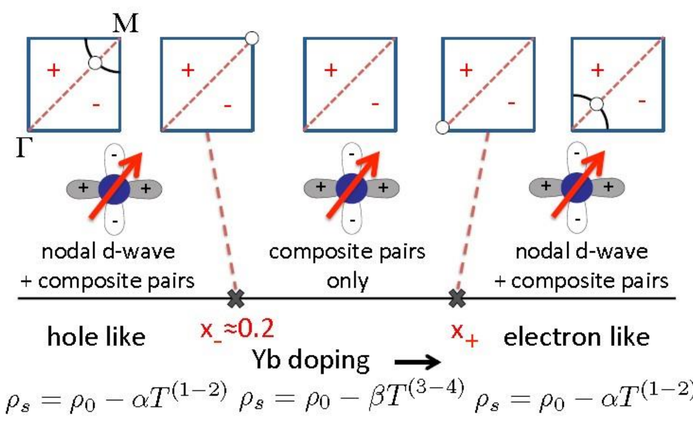
Superfluid density ( $\rho \sim \lambda^{-2}$ )




Linear? Or Nonlinear? More points are needed

F. and H. London 1935

## A theory of linear doping dependence of $T_c$




$$\rho_s = \rho_0 - \alpha T^{(1-2)} \quad \rho_s = \rho_0 - \beta T^{(3-4)} \quad \rho_s = \rho_0 - \alpha T^{(1-2)}$$

The composite pairs only created at Ce sites in three dimensions:

$$T_c \approx T_c(0) \times (1-x)^{3/2}$$

Given the uncertainty in doping levels, the new theory provides a qualitative fit to the linear doping dependence of $T_c$

P.Coleman *et. al*. 2014

## Conclusions

1. Composite pairing provides a natural explanation for the unusual linear doping dependence of $T_c$ and superfluid density of $Ce_{1-x}Yb_xCoIn_5$.

2.The existing data are not enough to confirm the theory, more substitution points are needed.

## Acknowledgements

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