Testing the cold dark matter model with cluster mass distributions

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Exploring the outskirts of galaxy clusters

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Distribution of DM
Mass in clusters

OBSERVATION
GAS TEMPERATURE
GAS DENSITY

Hydrostatic EQ

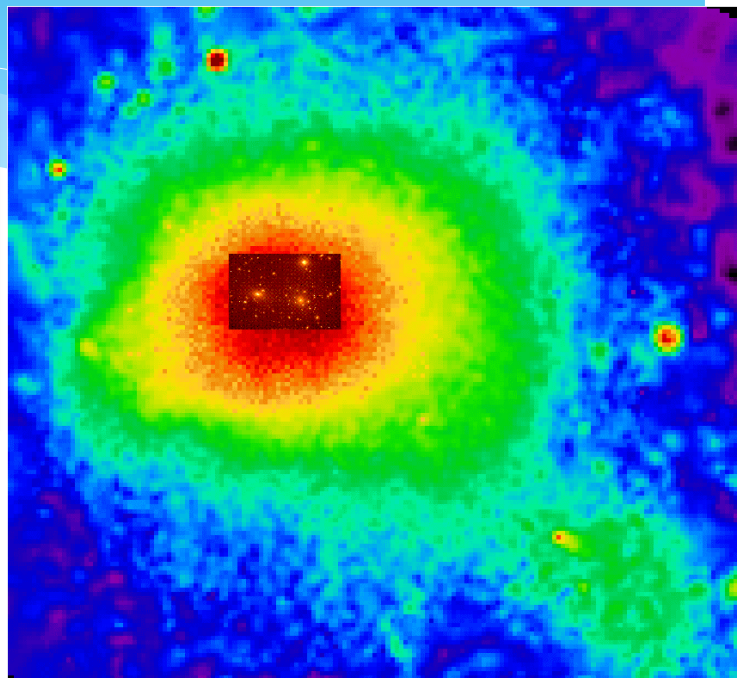
Total dynamical Mass (Vikhlinin+06)

Baryon substraction

THEORY
DM model
SFDM,CDM

Predicted by model

DM mass



e.g. Coma cluster
ROSAT X-ray image from NASA HEASARC

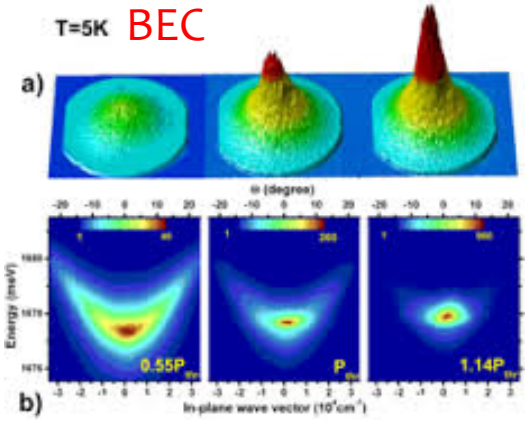
Scalar Field Dark Matter (SFDM) model (review Robles+2013)

Basic Properties:

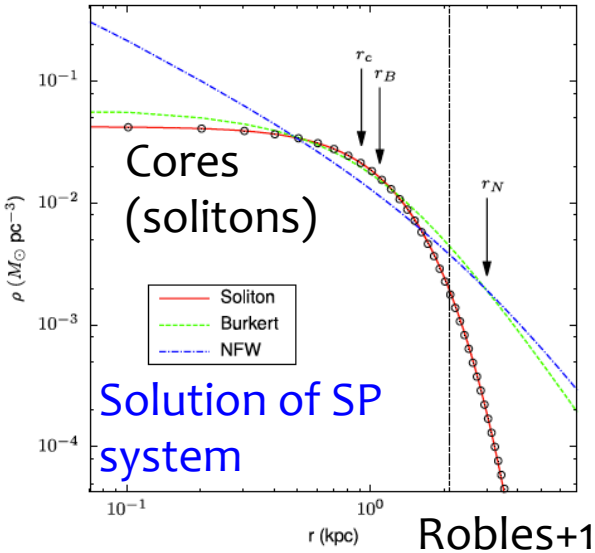
- DM is a spin-0 scalar field of $m_\psi <\sim 10^{-14} eV/c^2$ ($m_\psi \sim 10^{-22} eV/c^2$)
- High condensation temperature imply a cosmological BEC

Compton wavelengths overlap: "particles" are of sizes ~ 1 kpc

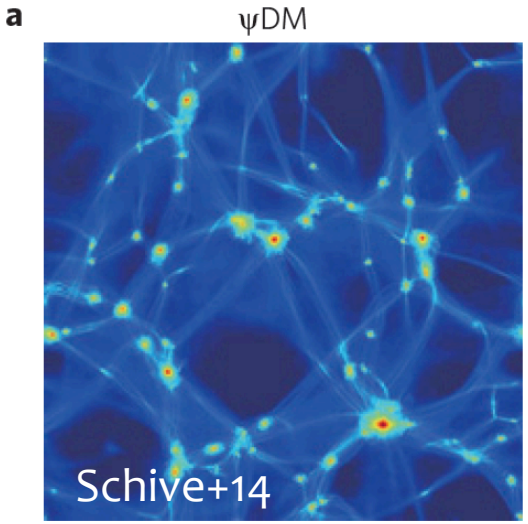
} DM candidate: PSYON

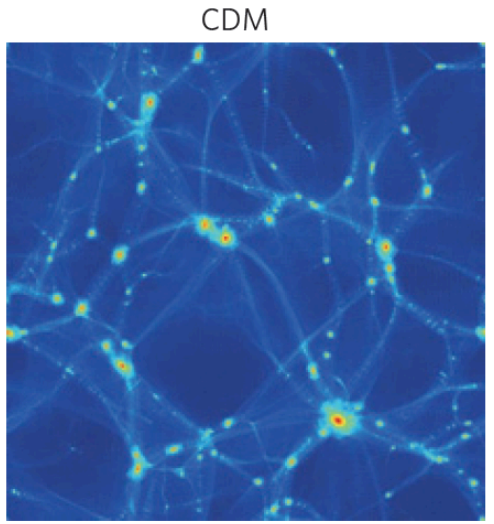


Discrepancies	CDM	SFDM
Cusp-core issue	Requires baryons	DM only
Satellite abundance	Many halos but no galaxies?	No low mass halos,no gal.!
Too big to fail	MW w disk + baryons	Is it present?



Robles+12,13,15





SFDM: Modeling DM in halos

Analytical solution (Robles & Matos 2012, 2013)

$$\rho(r) \propto |\psi(r)|^2$$

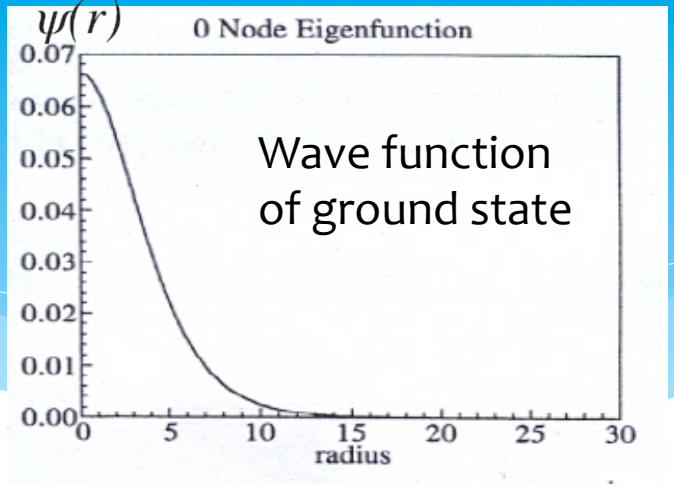
$$\rho_j(r) = \rho_0^j \frac{\sin^2(k_j r)}{(k_j r)^2}, \qquad k_j = \pi j / R$$

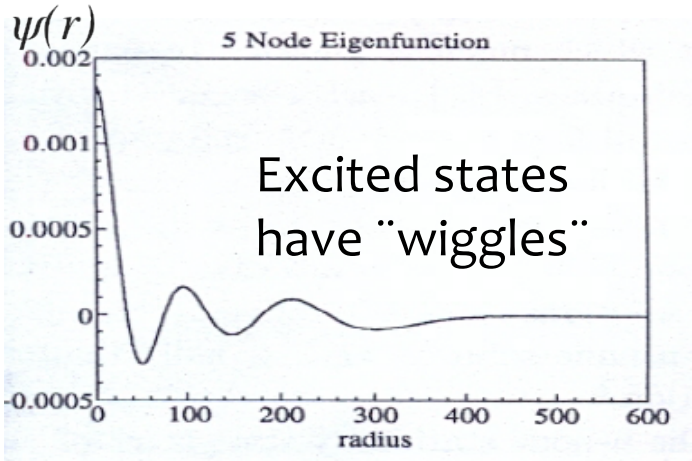
R_j is halo size: $\rho(r=R)=0$

$$M_j(r) = \frac{2\pi\rho_0}{k_j^2}\left[r - \frac{\sin(2k_j r)}{2k_j}\right]$$

CDM: NFW profile

$$M_{\mathrm{NFW}}(r) = 4\pi\rho_s r_s^3\left[-\frac{r}{r+r_s} + \ln\left(1+\frac{r}{r_s}\right)\right]$$

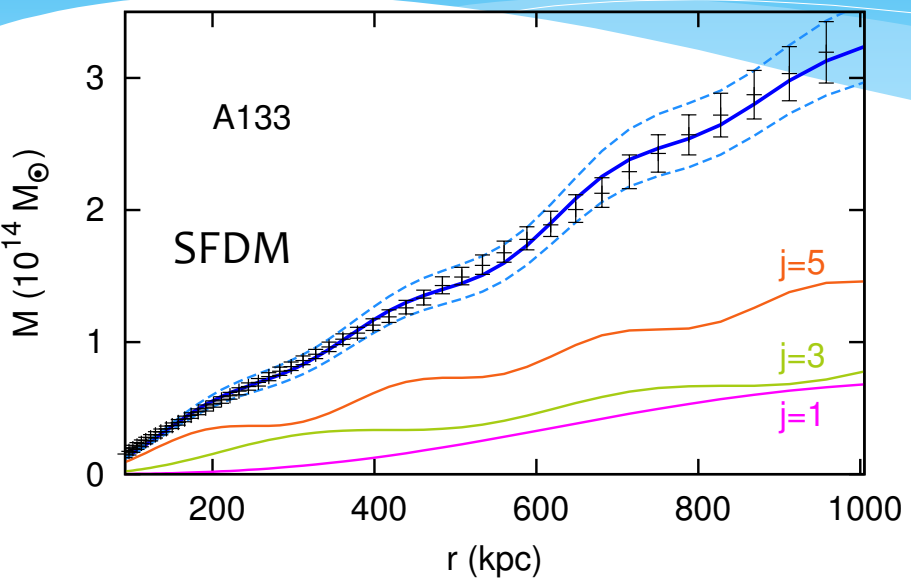




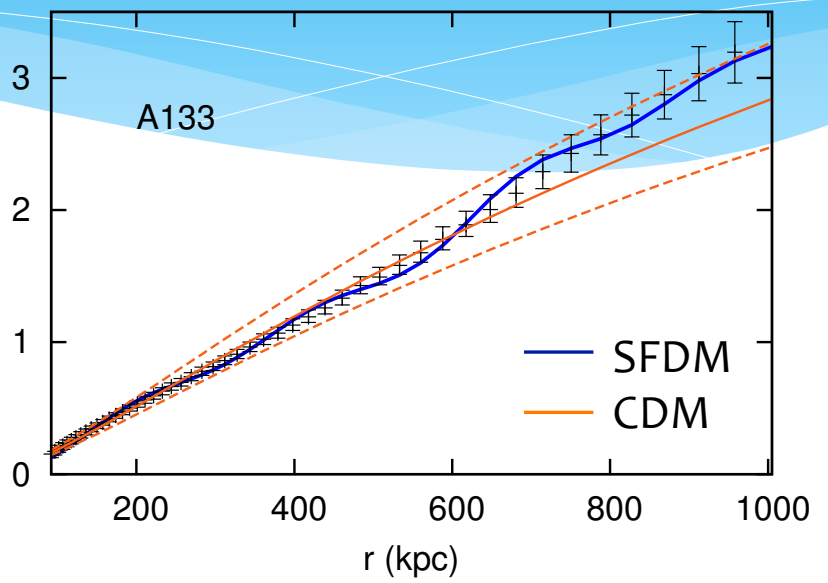
In general we could get a superposition of states

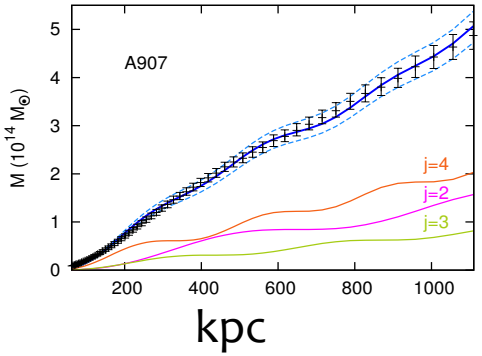
Results: Fits to inferred cluster DM mass

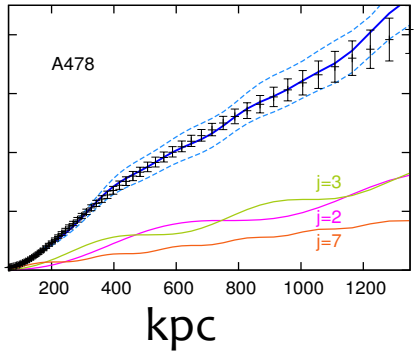
SFDM(Robles,Bernal&Matos16)



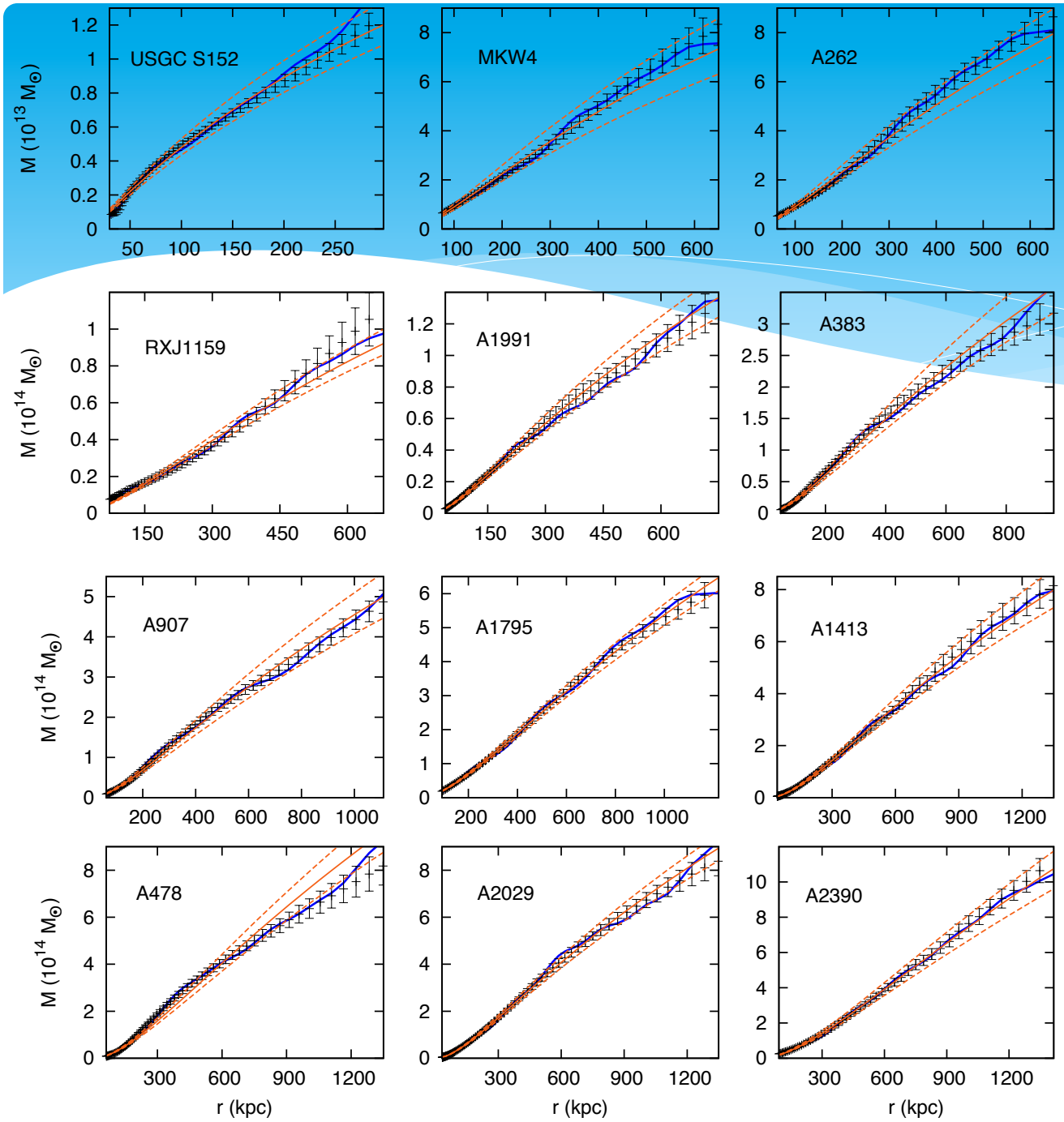
CDM (Vikhlinin+06)







- Superposition of states in a halo reproduce the observed DM profile.
- SFDM preditcs features in the mass profile & improves the fit.
- Excited states also necessary for large individual galaxies (Robles+13,15)



Main conclusions:

-Excited states of SFDM account for a wide range of Cluster profiles

-Their average contribution is ~60% of the total DM mass

-Mass profile fits in SFDM slightly better than CDM

-Weak lensing could disentangle these models