X-ray Observations

• Bulbul et al. (submitted ApJ)
  • 73 clusters with $XMM$-Newton, MOS + PN CCDs
  • stacking $z = 0.01$ to 0.35 clusters
  • blends features in the instrument response function
  • increases total exposure
• 4 - 5$\sigma$ in full MOS data set
  • found in several subsets of observations
  • $\rightarrow$ Trials factor unnecessary
• Indications at 2.2$\sigma$ Perseus with $Chandra$
• Not seen in Virgo, but consistent upper limit

• Boyarsky et al. (in press, PRL)
• Andromeda indication at 3$\sigma$ - $XMM$-Newton
• Perseus indication at 2.3$\sigma$ - $XMM$-Newton
• Combined detection at 4.4$\sigma$
Exact Shi-Fuller Parameter Space & Structure Formation

Abazajian, PRL, arXiv:1403.0954
Exact Shi-Fuller Parameter Space & Structure Formation

Cluster Signal

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M31 limit

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Model Cases

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$\sin^2 \theta$

$\mu^2 f(\epsilon) (\times 100)$

$\epsilon = p/T$

$7$
$7.2$
$7.4$

$7 \text{ keV}$

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Lepton # Models

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Equivalent thermal WDM

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Equivalent thermal WDM

Lepton # Models

1.
6 keV

2.
0 keV

2.
9 keV
Future Technology/Experiment

Testing the X-ray line from Dark Matter
Future: International X-ray Observatory Class Mission?

Abazajian 2009
Confirmation: Astro-H launches 2015

Astro-H SXS
Perseus, 1 Msec
kT = 6.5 keV, 0.6 solar
z=0.0178
v(baryons) = 300 km/s
v(line) = 1300 km/s

Bulbul et al. arXiv:1402.2301
Proposal for a “Smoking Gun” Signal with Chandra

Abazajian et al. 2014 Chandra X-ray Visionary Program Proposal
Proposal for a “Smoking Gun” Signal with Chandra

Andromeda (M31) has a massive, nearby dark matter halo with no known X-ray sources off-center

5.5 Ms observation at 30’ off-center

provides a 4.2σ detection of the observed line

10 Ms would be 5.8σ discovery

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Guaranteed Proposal Success

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Confirmation Wish List: Line Flux Profile

M31 surface brightness profile:
- on-center
- off-center upper limit
- NFW, c = 11.7
- NFW, c = 19

Perseus cluster surface brightness profile:
- NFW DM line, r_s = 360 kpc
- NFW DM line, r_s = 872 kpc
- β-model, β = 0.71, r_s = 287 kpc
Confirmation Wish List: searches in nuclear $\beta$-decay & EC capture

Laboratory Limits: $\nu_e \leftrightarrow \nu_s$