Update on the 3.5 keV Candidate Dark Matter Decay Signal

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With
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INTRODUCTION

WIMP Vs SUPERWIMP

WIMPs
- Interaction strength at weak scale
- Correct $\Omega_{DM}$ for masses Gev - TeV
- Would have short lifetime
- Made stable with new physics

SUPERWIMPS
- Interaction strength weaker-than-weak
- Correct $\Omega_{DM}$ for masses of order keV
- Lifetime longer than age of universe
- Allowed to be decaying DM
Decaying DM should decay into monochromatic X-rays
TARGET SOURCES

Good targets are dark matter dominated. Specifically, sources with high expected decay signal strength

\[ \text{signal} \propto \text{DM mass in FoV} / \text{distance}^2 \]
Detection at $E \sim 3.5$ keV

Andromeda (M31) (Boyarsky et al. 2014a [1402.4119])
# Detections of the Unidentified 3.5 keV Line

**Boylarsky et al. 2014a,b** [1402.4119, 1408.4388]

<table>
<thead>
<tr>
<th>Location</th>
<th>Instrumentation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>M31 galaxy</td>
<td>XMM-Newton, center &amp; outskirts</td>
<td></td>
</tr>
<tr>
<td>Perseus cluster</td>
<td>XMM-Newton, outskirts only</td>
<td>4.4σ</td>
</tr>
<tr>
<td>Blank sky</td>
<td>XMM-Newton</td>
<td><em>No detection</em></td>
</tr>
</tbody>
</table>

**Bulbul et al. 2014** [1402.2301]

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<th>Location</th>
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<tr>
<td>73 clusters</td>
<td>XMM-Newton (MOS &amp; PN), centers only, up to $z = 0.4$</td>
<td>5σ &amp; 4σ</td>
</tr>
<tr>
<td>Perseus cluster</td>
<td>Chandra, center only</td>
<td>3.5σ</td>
</tr>
</tbody>
</table>
**Instrumental origin unlikely**

- Detected in 4 different detectors
- Line redshifts correctly with sources
- Not detected in blank sky dataset
**ATOMIC LINE?**

Unlikely: can not explain consistently all observations

M31 line is **stronger** than other atomic emission

CLUSTERS need **anomalous line ratios** of a factor $\sim 20 - 30$

Bulbul et al. 2014
The line flux should be proportional to mass / distance$^2$
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Expect large signal from GC → “easy” cross-check
Boyardsky et al. 2014b [1408.4388]
Boyarsky et al. 2014b [1408.4388]
MORE PERSEUS

Preliminary 1 Ms with Suzaku, 3σ detection in the center

Franse, Bulbul et al. (in prep)
We have been awarded 1.4 Ms of XMM observations of the Draco dwarf galaxy this year

- Nearby, dark matter dominated object
- Highest expected signal of all dwarf galaxies (Geringer-Sameth+ 2014, Lovell+ 2014)
- Very gas-poor (*do not expect any atomic lines*)
- We will be able to confirm or deny the DM origin of the 3.5 keV line somewhere in 2016.
**Draco dSph Observation Projections**

- **Blank-sky**
- **Perseus**
- **GC**
- **M31**

- Line flux, $10^{-6}$ photons cm$^{-2}$ s$^{-1}$
- Projected DM mass density, $M_{\text{Sun}}$/pc$^2$

- $\tau_{DM} = 2.1 \times 10^{27}$ sec
- $\tau_{DM} = 15.6 \times 10^{27}$ sec

- Bulbul et al. (2014)

- Stacked dSph bound

- TAUP 2015, Torino, Sept 9 2015
PARAMETER SPACE

DM overproduction

Excluded by X-ray observations

Not enough DM

Interaction strength $\sin^2(\theta)$

Dark matter mass $M_{DM}$ [keV]