A search for dark matter annihilation in the newly discovered dwarf galaxy Reticulum II

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Table 1. Detection of new satellite galaxy candidates in DES Y1A1

<table>
<thead>
<tr>
<th>Name</th>
<th>Right Ascension</th>
<th>Declination</th>
<th>Magnitude</th>
<th>Half-light Radius</th>
<th>Scan TS</th>
<th>Fit TS</th>
<th>Map Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>DES J0335.6-5403</td>
<td>53.92</td>
<td>-54.05</td>
<td>17.5</td>
<td>0.1</td>
<td>1466</td>
<td>0</td>
<td>1713</td>
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<td>24.6</td>
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<td>0.01</td>
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<td>30.3</td>
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<td></td>
<td>19.4</td>
<td>19.4</td>
</tr>
</tbody>
</table>

Note. — Best-fit parameters from the maximum-likelihood fit assuming the composite isochrone described in Section 3.2. Uncertainties are calculated from the highest density interval containing 90% of the posterior distribution. "Map Sig" refers to detection significance of the candidate from the stellar density map search method (Section 3.1). "TS Scan" refers to the significance (Equation 4) from the likelihood scan using a Plummer model spatial kernel with half-light radius $r_h = 0.1$ (Section 3.2). "TS Fit" denotes the significance of the likelihood method using the set of best-fit parameters. Ellipticities and position angles are not quoted for lower significance candidates where they are not well constrained by the data.

Fig. 2.— Left: False color gri coadd image of the 0.3"x0.3" region centered on DES J0335.6-5403. Right: Stars in the same field of view with membership probability $p_i > 0.01$ are marked with colored circles. In this color map, red signifies high-confidence association with DES J0335.6-5403 and blue indicates lower membership probability. The membership probabilities have been evaluated using Equation (2) for the best-fit model parameters listed in Table 1.

In collaboration with Matt Walker (CMU) Savvas Koushiappas (Brown) Sergey Koposov, Vasily Belokurov, Gabriel Torrealba, Wyn Evans (Cambridge) Vincent Bonnivard, Celine Combet, David Maurin (LPSC Grenoble)

Dark matter

Annihilation $\langle \sigma v \rangle$

Weak scale

Always* get gamma-rays
Milky Way dwarf galaxies

Gamma-rays — Fermi satellite

Nearby

Lots of dark matter

Not much else —> no astrophysical background
Reticulum II

nearest of the new DES dwarfs (30 kpc)
(Koposov+ 2015, Bechtol+ 2015)
A suggestive feature?

Events within 0.5° of RetII

Geringer-Sameth+ arXiv:1503.02320 (PRL)
Statistical procedure

Quantify the significance of the signal (e.g. $p$ value)

Each photon gets a weight

$$T = \sum_{i \in \text{photons}} w(Q_i)$$

sum over all observed events

$$w_Q = \log \left( 1 + \frac{s_Q}{b_Q} \right)$$

signal

background

Local $p$-value < $3 \times 10^{-5}$ (4σ) in every channel

Robust to different background spectra

with trials, $p_{\text{global}} < 9.8 \times 10^{-5}$
Empirical background sampling

Local $p$ value of $8/3306 = 0.0024$ (2.8$\sigma$)

Global $p$ value of $32/3306 = 0.0097$ (2.3$\sigma$)
If signal is due to dark matter annihilation, what can we say about the dark matter particle?

\[ \log_{10} J \gtrsim 19.6 \pm 0.3 \]
Use line of sight velocities + Jeans equation to infer dark matter density profile

Use line of sight velocities + Jeans equation to infer dark matter density profile

Bonnivard et. al. arXiv:1506.08209
Hurdles for any dark matter interpretation

1. Gamma-ray data is inconsistent with background

2. Consistent with dark matter annihilation
   - Energy spectrum of signal
   - Dark matter halo of RetII

3. Inconsistent with any other possible source
   - Distant source coincidentally in same direction — related to (1)

   Instrument/data, Pass 8
   Drlica-Wagner+ (Fermi,DES) 1503.02632 (ApJL)
   Hooper & Linden 1503.06209