Decaying dark matter in dwarf spheroidal galaxies

Prospects for X-ray and gamma-ray telescopes (astro-ph/2103.13242)

We study the detectability of signatures of dark matter decay in current and future generation X-ray and gamma-ray telescopes. We consider both keV sterile neutrinos and TeV-PeV heavy dark matter. We target dwarf spherioidal galaxies due to their relative paucity of astrophysical material, which makes them ideal for possible indirect detection searches.

Differential flux of photons from dark matter decay is given by

$$\frac{dF}{dE} = \frac{\Gamma_\chi}{4\pi m_\chi} \frac{dN_{\rm decay}}{dE} D$$

STERILE NEUTRINOS

The conversion probability of a sterile neutrino into an active neutrino is proportional to $\sin^2 2\theta$,where θ is the mixing angle.

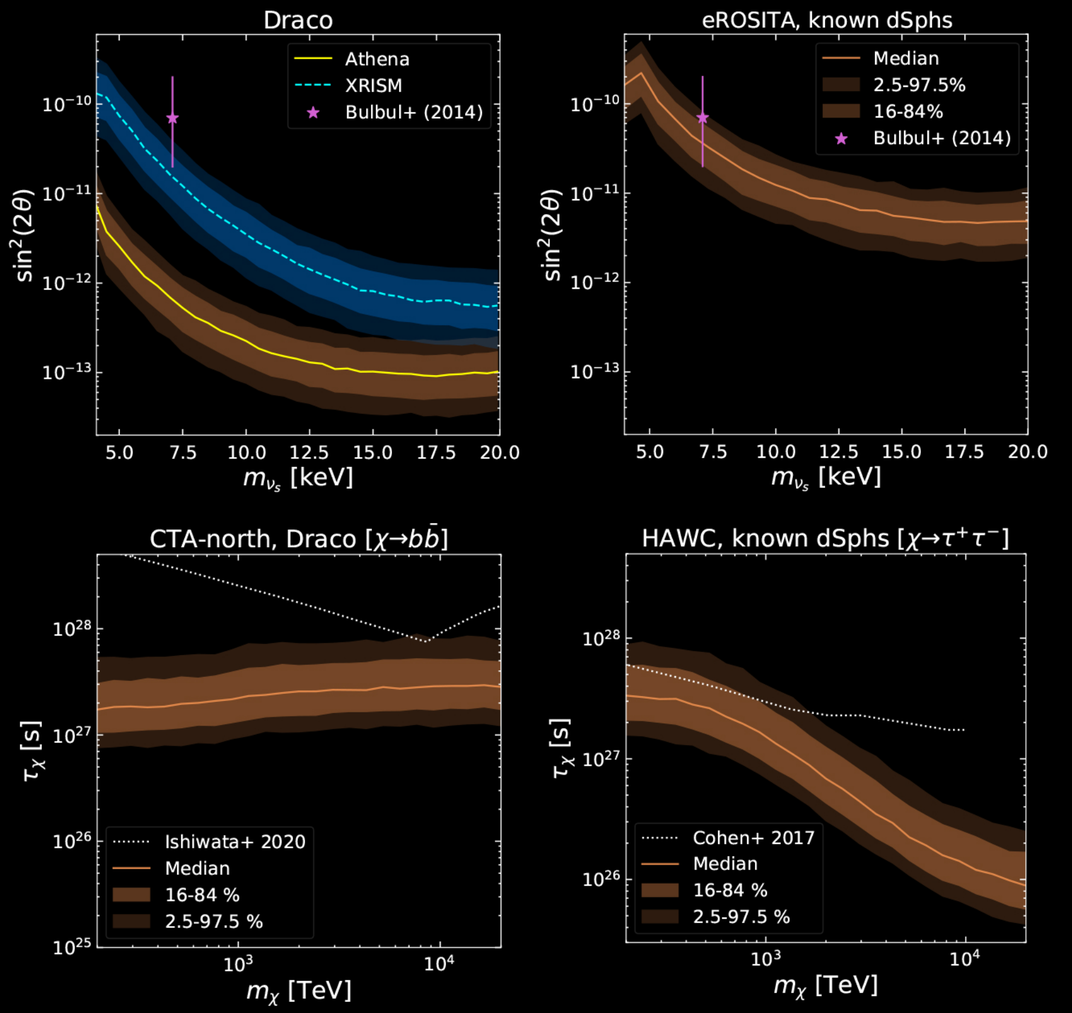
$$\Gamma_{\nu_s}(m_{\nu_s}, \theta) =$$

$$1.38 \times 10^{-29}\ \mathrm{s}^{-1} \left(\frac{\sin^2 2\theta}{10^{-7}}\right) \left(\frac{m_{\nu_s}}{1\ \mathrm{keV}}\right)^5$$

HEAVY DARK MATTER

We consider particles in the range 200 TeV to 20 PeV. Decay products hadronize to produce gamma-rays. For particle masses above 200 TeV, we use the following energy scaling.

$$\frac{dN}{dE} = \frac{m_A}{m_\chi} \frac{dN_A}{dE'} \quad (E' = E\frac{m_A}{m_\chi})$$



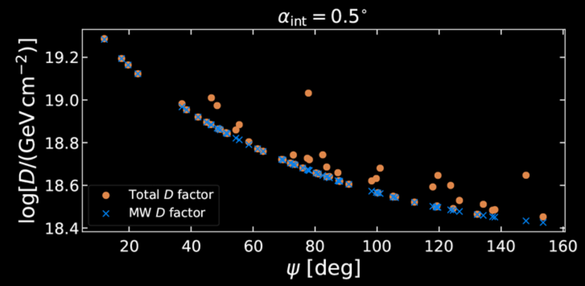
FIGURES

Upper left/right: Upper limit on mixing angle as a function of sterile neutrino mass for each of the considered X-ray telescopes. Lower left/right: lower bounds on dark matter decay life time for tau-tau and b-bbar decay channels for CTA-north and HAWC observatories. Inset: D factors as a function of galactic coordinate showing contribution from Milky Way and simulated dwarfs.

DETECTABILITY ANALYSIS

Using D factors for known dwarf galaxies and adding the expected additional D factor due to the Milky Way, we make projections for the sensitivity to keV sterile neutrino decay in eROSITA, XRISM and Athena X-ray telescopes.

In case of heavy dark matter, we make projections for CTA and HAWC gamma-ray observatories. For eROSITA and HAWC, we investigate how prospective dwarfs discovered by the LSST influence sensitivity to decay signatures.



RESULTS

We conducted a comprehensive study of dark matter decay signatures for dwarf spheroidal galaxies in the Milky Way Galaxy.

For all considered x-ray telescopes, the 3.5 keV is able to be critically assessed and its implications on the properties of sterile neutrino dark matter can be explored. Considering eROSITA, Athena and XRISM telescopes, we find that these instruments are able to probe mixing angles down to 10^{-12} - 10^{-10}, with Athena giving the strongest constraints.

For heavy dark matter, we find to HAWC and CTA are able to probe lifetimes up to 10^{27} - 10^{28} s. We find weaker constraints for the $\tau^+\tau^-$ channel than for the $b\bar{b}$ channel.

AUTHORS

Shin'ichiro Ando, Suvendu K. Barik, Zhuoran Feng, Marco Finetti, Andreas Guerra Chaves, Sahaja Kanuri, Jorinde Kleverlaan, Yixuan Ma, Nicolo Maresca di Serracapriola, Matthew S. P. Feinema, Imanol Navarro Martinez, Kenny C. Y. Ng, Ebo Peerbooms, Casper A. van Veen and Fabian Zimmer.