Has Sterile Neutrino Dark Matter been Detected?

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The sterile neutrino dark matter particle forms part of a theory that, in addition to dark matter, solves the problem of why standard model neutrinos have mass and why there is more matter than antimatter in the Universe. Some of the parameters of this parent particle physics theory will be constrained by upcoming particle physics experiments. A further subset of the parameters also set the kinematic properties of the dark matter, to the degree that the abundance and structure of galaxies is altered. Finally, the same particle physics properties control how readily the sterile neutrino decays into X-ray photons, a candidate signal of which has been detected at an energy of 3.55keV and is consistent with a 7.1keV mass sterile neutrino.

This analysis — measuring the X-ray line properties, building the particle physics models, dove-tailing the particle physics with the galaxy formation models, and comparing the results to observed galaxies — requires a multi-field collaboration that involves X-ray astronomers, particle physicists, galaxy formation theorists and observers of galaxies. At this workshop our goal was to bring together researchers from these four fields to answer two main questions, namely to evaluate the current evidence for and against sterile neutrinos as dark matter, and to devise further tests to obtain more evidence in either direction.

We succeeded in broadening our mutual understanding of the opportunities and challenges of the various fields involved in sterile neutrino studies: from the difficulties of modelling X-ray spectra to an appreciation of the power of lensing studies. We considered new techniques with which to test the sterile neutrino dark matter hypothesis, and ultimately drew up a list of the methods that will provided the strongest constraints / probability of detection: X-ray observations, lensing studies, and eventually particle physics experiments.

We concluded by drawing up a timeline over which we expected the various probes to yield results: lensing studies and Lyman-alpha forest constraints by 2020; followed by X-ray observations of the Perseus cluster (XARM), the Milky Way Galactic Centre (Micro-X), and results from the KATRIN neutrino experiment in 2022. If these studies provide further evidence in favour of sterile neutrino dark matter, we anticipate that support will build within the wider community to make a financial and technological commitment towards building an experiment that will detect the sterile neutrino dark matter particle directly. Together with results from the proposed SHiP experiment and further X-ray work done with the ATHENA satellite (2028), we will be able to answer whether the sterile neutrino is indeed the dark matter.

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