Can the excess in the FeXXVI Lyγ line from the Galactic Center provide evidence for 17 keV sterile neutrinos?

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The standard model of particle physics assumes that neutrinos are massless, although adding non-zeros is required by the experimentally established phenomenon of neutrino oscillations requires neutrinos to have non-zero mass. Sterile neutrinos (or right-handed neutrinos) are a good warm dark matter candidate. We find that the excess of the intensity in the 8.7 keV line (at the energy of the FeXXVI Lyγ line) in the spectrum of the Galactic center observed by the Suzaku X-ray mission cannot be explained by standard ionization and recombination processes. We suggest that the origin of this excess is via decays of sterile neutrinos with a mass of 17.4 keV and estimate the value of the mixing angle. The estimated value of the mixing angle $\sin^2(2\theta) = (4.1\pm2.2)\times10^{-12}$ lies in the allowed region of the mixing angle of dark matter sterile neutrino with a mass of 17-18 keV.

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I. INTRODUCTION

Several astrophysical observations, such as the indications of central cores in low-mass galaxies, the low number of satellites observed around the Milky Way, and the near constant cores of the least luminous satellites, have revived interest in sterile neutrinos as a warm dark matter candidate. Electroweak singlet right-handed (sterile) neutrinos with masses in the few keV range naturally arise in many extensions of the Standard Model and could be produced in the early universe through the Dodelson-Widrow mechanism involving (non-resonant) oscillations with active neutrino species [1]. The experimentally established phenomenon of neutrino oscillations requires neutrinos to have non-zero mass, and sterile neutrinos (or right-handed neutrinos) are a natural warm dark matter candidate.

Direct constraints on masses and mixing angles are obtained both from the Lyman alpha forest power spectrum and X-ray observations of the radiative decay channel, the latter providing a photon with energy $E=m_s c^2/2$, where m_s is the sterile neutrino mass. Most recently, X-ray observations of the local dwarf Wilman 1 have shown marginal evidence for a 5 keV sterile neutrino [2]. The inferred mixing angle lies in a narrow range for which neutrino oscillations can produce all of the dark matter and for which sterile neutrino emission from cooling neutron stars can explain pulsar kicks.

In fact if sterile neutrinos provide a significant fraction (although not necessarily all, see [3],) of the dark matter, the Galactic Center provides an even more attractive environment to search for radiative decay signals. If the sterile neutrino mass is indeed around 17 keV, we expect a X-ray line near 8.5 keV. The diffuse X-ray emission from the Galactic Center using the X-ray imaging spectrometer on Suzaku was analyzed by [4], who detect the 8.7 keV line corresponding the FeXXVI Lyγ. We have reanalysed the data on hydrogen-like iron line strengths and find that there is an unexpected excess in the 8.7 keV line from the Galactic center in the Suzaku data. We demonstrate that this excess cannot be explained by means of standard ionization and recombination processes. We propose an explanation of the excess in the 8.7 keV line in terms of 17.4 keV neutrino decays.

II. THE EXCESS IN THE 8.7 KEV LINE FROM THE GALACTIC CENTER AND ITS ORIGIN

X-ray emission from the Galactic center has been observed for almost 30 years. A component of the diffuse emission is thermal and is produced by a high temperature plasma in the inner 20 parsecs of the Galactic Center ($\sim$ 8 keV). The most pronounced features in the emission lines are Fe I Kα at 6.4 keV, and the K-shell lines 6.7 and 6.9 keV from the helium-like (FeXXV Kα) and hydrogen-like (FeXXVI Lyα) ions of iron, respectively. An analysis of the ratio of the 6.7 keV to 6.9 keV lines is an interesting test of plasma components (see, e.g. [5], [6]). For the first time, the FeXXVI Lyγ at 8.7 keV was detected by the Suzaku X-ray mission [4]. The observed line intensities by Suzaku are listed in Table 2 of [4]. For convenience, we list below the most important lines (for our analysis) taken from the paper by [4]. The measured intensities of the lines of the hydrogen-like iron ions are: $I_{\mathrm{Ly}\alpha} = 1.66^{+0.09}_{-0.11}\times10^{-4}$ ph/(cm^2 s), $I_{\mathrm{Ly}\beta} = 2.29^{+1.35}_{-1.31}\times10^{-5}$ ph/(cm^2 s), and $I_{\mathrm{Ly}\gamma} = 1.77^{+0.62}_{-0.56}\times10^{-5}$ ph/(cm^2 s). The errors are at 90% confidence level [4].

The measured ratio of the FeXXVI Lyβ to FeXXVI Lyα iron lines equals $\approx 0.138 \pm 0.059$ and is in agreement with the theoretical value of ≈ 0.14 in the gas temperature range between 5 and 15 keV (see line list [7]; for a review, see [8]).

We note that the measured intensity of the FeXXVI Lyγ = $1.77^{+0.62}_{-0.56}\times10^{-5}$ ph/(cm^2 s) iron line has an significant excess above the value derived from the theoretical model [7] and the measured intensity $I_{\mathrm{Ly}\alpha}$ of the FeXXVI Lyα iron line. The ratio of the the FeXXVI Lyγ to FeXXVI Lyα iron lines equaled 0.038 in the gas temperature range between 5 and

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