Improving our knowledge of the distant X-ray Universe via gravitational lensing: RCS2 032327-132623, a case study

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Introduction: We report on our X-ray analysis of the field of RCS2 032327-132623 (J0327 for short, z = 0.564, lensed galaxy z = 1.5) The analysis has yielded three phenomena that are on one hand interesting and on the other hand require follow up to determination of their precise origin. The primary effect we discovered is a 1.47 keV line whose origin could be diffuse or point-like. If point-like, the line is most likely due to Fe emission from a highly magnified AGN. If instead the line is coming from diffuse emission, then again Fe line emission from a magnified background cluster is most likely, with sterile neutrino decaying being a distant third explanation. In any regard, a key point is for any background (a foreground is excluded as this should produce a Fe line between 4.3 and 6.7 keV) object, the reason we are able to detect the line is only because it has been highly magnified by gravitational lensing of the foreground cluster. In this paper we give details about the line and then discuss two other ancillary effects we want of follow up. The results demonstrate the value of searching rich clusters of galaxies with high magnification for, otherwise impossible-to-detect distant X-ray emitting objects. This field is filled with enigmas and it was sad our follow up Chandra request was turned down.

Primary Enigma: What is the origin of the line seen at about 1.47 keV?

A best guess that needs to be confirmed with a deeper Chandra image is a line-of-sight highly magnified AGN with a 6.4 keV intrinsic emission. Redshift then would be \(1+z = 6.4/1.47 ≈ 4.35\) (z = 3.35). An alternative, at slightly higher redshift \(z = 3.55\) would be a cluster with Fe in the intracluster medium. Confirmation of either would be exciting yet needs a deeper Chandra exposure as can be seen here in what we could dig out of the current 60 ksec exposure.

Discussion:

- Try as we might, with a total of just 1,000 counts there was just not enough to tell us if there is diffuse or point-like background source causing the line.
- We have modelled a background line plus continuum to show that a back ground continuum would not significantly be detected on top of the cluster continuum.
- We have point source guesses based on IRAC source inside X-ray contours Fig 4; nothing convincing or that is consistent with a bright IR source indicative of an AGN.
- There is nothing convincing in the way of a concentration of optical/NIR objects or diffuse X-ray emission that would indicate a distant cluster.
- Yet, an extremely redshifted iron line is more likely than any other lower energy line. Lower energy lines should have companion lines which are not seen.
- Ancillary science is there are hints of X-ray emission seen from the tips of the lensed galaxy, which would be the first detection of a lensed normal galaxy in X-rays.
- With a better aim-point, the diffuse emission of the \(z = 0.56\) cluster could be measured, and based on the BCG offset from the X-ray centroid, we will find another “Bullet Cluster”-like event from which we can derive a limit to the CDM self-interaction cross section.

Summary and Conclusions: We have found an emission line in the direction of a rich cluster that is producing giant arcs. Due to strong magnification, it is likely that a background AGN or a rich cluster is the source, without being outrageously luminous even though at \(z = 3.5\). A magnification of 10 implies a \(L_x\) of about 3E44 ergs/sec at \(z = 3.5\). This \(L_x\) is based on assuming the maximum of 10% of the total flux we’ve detected is from the background. The actual total contribution is between 1% and 5%. There are also hints of X-ray emission from the tips to the z = 1.5 normal galaxy and that we have detected a cluster merger in progress. In total, the only 60 ksec current observation was not enough for firm conclusions. Thus, it is a shame our Chandra cycle 16, 120 ksec re-observation request was not approved. Ref: Sharon et al., 2012, ApJ, 746, 161