The X-ray Cluster in Front of PG1407+265

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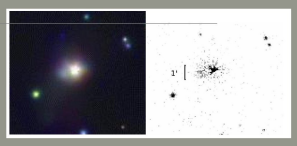
An odd quasar and its environment

PG1407+265 (McDowell et al 1995, ApJ 450, 585) is a z=0.96 Weak Line Quasar (WLQ) with low equvialent width emission lines and large velocity shifts between the high and low ionization lines indicative of a 10000 km/s outflow. Unlike BL Lac objects it is formally radio quiet, although Blundell, Beasley and Bicknell (2003, ApJ591,L103) found a stunted relativistic radio jet. Unlike the X-ray weak WLQs such as PHL 1811 (Leighly et al 2007, ApJ 663,103; Luo et al 2015, ApJ805,122), PG1407+265 is a bright X-ray source.

We wondered if the strange properties of PG1407+265 might be asssociated with an unusual environment or possibly foreground lensing, motivating a search for an X-ray cluster in its vicinity.

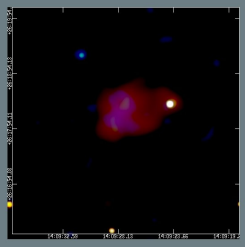
We reexamined the 2001 XMM observation and found evidence for such a cluster, and followed up with Chandra observations coupled with ground based spectroscopy. It turns out that there is an X-ray cluster about one arcminute from the quasar, and it is a foreground object at z=0.68.

XMM imaging hints at a previously unknown cluster of galaxies



XMM MOS image of PG1407+265 (left) and PSF-subtracted image (right). There's definitely something there but the uncertainties in the PSF subtraction prevent quantitative analysis. Time for more spatial resolution - and that means Chandra. (see center panel.)

Presenting CXOU J140927.9+261813: Chandra imaging resolves a cluster next to a bright quasar.



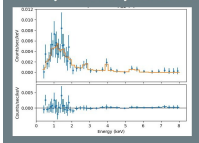
The newly discovered cluster: adaptively smoothed X-ray color image (red 1.0-1.5 keV, green 1.5-2.5 keV, blue 2.5-7 kev). The quasar PG1407+265 is the bright white source at right.

Angular size of the emission is about 1.0 by 1.5 arcminutes, corresponding to about 400 x 600 kpc at z=0.68. The cluster has a 0.5-10 keV unabsorbed flux of 8.2 x 10^{-14} erg/cm^2/s.
From MMT spectroscopy (right), and the Chandra spectrum

From MMT spectroscopy (right), and the Chandra spectrum (below), we infer that the cluster redshift is z=0.68, corresponding to a luminosity of

L(2-10 keV) = 1.2 x 10^{44} erg/s.

The temperature and mass are poorly constrained since there are only ~400 X-ray net counts in the cluster.

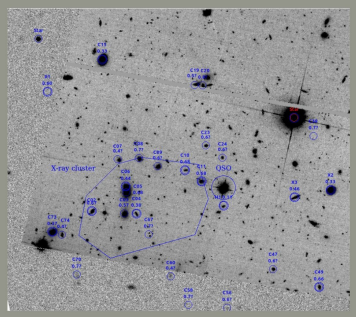


Chandra ACIS spectrum of the X-ray cluster fit with a MEKAL model at z=0.68 (with a redshifted iron line showing up at 4 keV). Two unidentified features at observed energies of 2.8 and 5.5 keV.

This observation shows the unique power of Chandra's high spatial resolution, allowing us to identify a cluster of galaxies previously lost in the glare of this bright quasar. How many other such missing clusters are there? eROSITA's imaging may not always be sharp enough to separate them out when they are next to or behind a bright quasar.

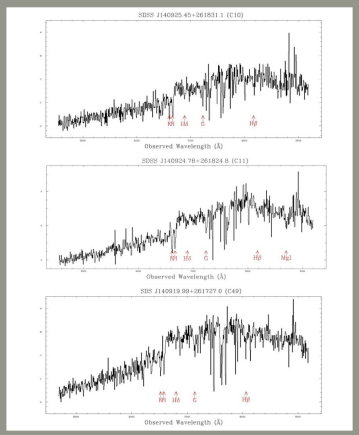
We acknowledge support from Chandra grant GO6-17117X and from the Chandra X-ray Center contract NAS8-03060. We thank MMTO/TDC staff for performing and reducing the MMT observations. The X-ray analysis was performed with CIAO 4.12 and 4.13.

High resolution HST/ACS imaging



Archival HST ACS image (PI: Lehner) overlaid on SDSS g-band image, indicating positions of quasar, cluster (polygon), and showing SDSS galaxies with MMT spectroscopic redshifts (double circles) and SDSS photometric redshift estimates (single circles).

Cluster member redshifts from MMT spectroscopy



Example spectra from our MMT BINOSPEC observations, showing three probable cluster members with z=0.68. Observations were made with the 270 lines/mm grating; the standard pipeline products are shown with candidate absorption line identifications indicated.