INTEGRAL, Chandra and XMM-Newton observations of the source ESO 575-G059

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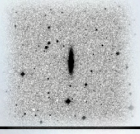
Synthesis models of the cosmic X-ray background show that a fraction of sources is missing to explain the spectrum of this diffuse background. It was suggested that a population of heavily obscured extragalactic objects were not fully sampled. Searching for the possible missing Compton-thick Active Galactic Nuclei (AGN) is therefore important. We thus searched for sources at the limit of detection in a very deep survey performed by INTEGRAL/IBIS ISGRI in the 3C273/Coma region. Among the AGN of our sample, we present here ESO 575-G059 for which we obtained a broad-band X-ray spectrum, using XMM-Newton/EPIC PN and INTEGRAL/IBIS ISGRI data and an optical spectrum. The source exhibits a hard spectrum, without the typical iron features usually observed in AGN. From optical observations, the source is classified as a Low Ionisation Nuclear Emission lines Region (LINER).

The target: ESO 575-G059

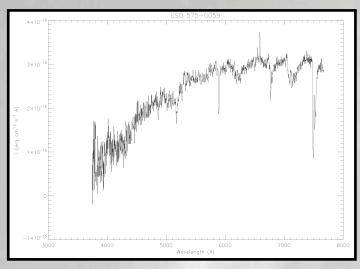
The source was just below the formal detection limit of five sigma in the deep INTEGRAL/IBIS ISGRI 3C273/Coma survey (Paltani et al. 2008). A single bright X-ray source was found in a Chandra/ACIS snapshot observation (2ks) with a high hardness ratio. ESO 575-G059 was confirmed as the counterpart of the hard X-ray source. The position of the X-ray source is consistent with the nucleus of the galaxy.



Classification: Sa0, edge-on galaxy
Nearby galaxy: z=0.0152
Coordinates (J2000): ra=13 07 43.9 ; dec=-19 23 43

Optical spectrum: a first idea

In order to find signatures of a nuclear activity, we carried out an optical follow-up of the source. The spectrum below was obtained by the 1.9 m Radcliffe telescope (South Africa), with an exposure time of 2x900s (see figure below).



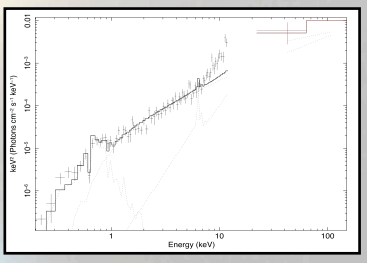
The spectrum first shows a red spectrum with no sign of stellar formation, as expected from the early-type morphological classification of the galaxy. We notice the strong [NII] double line at 6548 and 6583 Å. Although weak, the [SII] lines (at 6716 and 6731 Å) are also present. The [OIII] line is not detected and the Hα and Hβ emission lines are not prominent (they do not appear above the absorption line). A strong [NII] emission line compared to the Hα line is typical of a nuclear activity. But a weak [OIII] line compared to the Hβ line indicates that this source is not a Seyfert galaxy. It is classified as a Low Ionisation Nuclear Emission lines Region (LINER; Heckman 1980, Ho 1996), suggesting an important collisional ionisation. This class of objects is interesting as they could be the link between normal galaxies and AGN. Indeed, in the X-rays, LINER usually exhibit a low luminosity (in the 2-10 keV energy band) ranging from 10^{39} to 10^{42} erg/s (González-Martín et al. 2009a). If the dominant mechanism is still unclear, it is well accepted that a large fraction of LINER is associated with AGN. The X-rays are therefore a means to investigate the nature of AGN producing such LINER behaviour.

X-ray spectral fittings

Combining INTEGRAL/IBIS ISGRI data (289ks) and an XMM-Newton/EPIC PN observation (21ks), we analyzed the broad-band X-ray spectrum of ESO 575-G059, covering the 0.1-200 keV energy range.

Model 1: wabs*(powerlaw+apec)
We first fitted with a simple absorbed power-law and an optically thin plasma component (*apec* model in *xspec*) with a temperature of 0.30 keV. The fit is not acceptable but reveals a very hard photon-index: 0.34. A very hard X-ray spectrum can be the signature of a prominent reflection component over a strongly absorbed power-law continuum. We then tried to fit the spectrum adding a reflection component.

Model 2: $wabs_{gal}$*(wabs*cabs*cutoff+apec+reflection)
We added a reflection component using *pexrav* (which describes the reflection from neutral material) and Compton scattering model (*cabs*). We fixed the cut-off energy at 200 keV (Ricci et al. 2011) and the first hydrogen column density to the galactic value (6.46 10^{20} cm^{-2}). We also fixed the inclination angle to 45°. The fit is not good (X^2/dof=162/77). The photon-index, of 1.34, is more typical and the reflection fraction R, of 53.11, means that the true continuum is completely hidden.
As we did not detect the neutral iron emission line at 6.4 keV, we tried to fit the spectrum replacing *pexrav* by *pexmon* model which forces the reflection at the iron line. The fit is a little better (ΔX^2=-7) but the photon-index is again hard. In this fit, the reflection fraction becomes smaller and the N_H increases (1.6 10^{23} cm^{-2}). In any case, the spectrum shows a flat continuum and an additional hardening above 7 keV (see figure below).



The fitting parameters are summarized in the following table:

	N_H ($10^{22}cm^{-2}$)	Γ	R[a]	kT (keV)	X2/dof	P_{null}[b]	$L_{2-10keV}$ (erg/s)
pexrav	**2.03**	**1.34**	**53.11**	**0.62**	**162/77**	**10^{-8}**	**2.7 10^{41}**
pexmon	**16.73**	**0.65**	**10^{-4}**	**0.29**	**155/78**	**10^{-7}**	**2.5 10^{41}**

[a] Reflection fraction; [b] Null hypothesis probability

Nature of ESO 575-G059

ESO 575-G059 first exhibits a hard spectrum. It does not show a strong absorption, neither the expected neutral iron emission line at 6.4 keV. Because of the very hard spectrum, *pexrav* attempts to model the continuum with a purely reflection spectrum, which is inconsistent with the absence of iron features. *pexmon* allows to test the reflection scenario with the iron features treated consistently with the reflected continuum. Using *pexmon*, the reflection fraction is found to be negligible, and the model is dominated by the unabsorbed power-law. This allows us to exclude a reflection-dominated origin of the continuum in this object. In addition, the power-law fit is slightly better than the fit with *pexrav* (ΔX^2=-7).
The absence of iron line is however compatible with the LINER sources in general (Ho 2008). According to González-Martín et al. (2011), LINER sources can be explained by a complex absorbing structure or an inefficient mode of accretion onto a supermassive black hole. However, ESO 575-G059 does not show any signs of strong absorption. Its luminosity in the 2-10 keV energy band indicates a nuclear activity, through an accretion process. By its quite hard spectrum (Γ=0.65 in the best fit we obtained), ESO 575-G059 remains a puzzling source as low luminosity AGN normally exhibit a photon-index of 1.8 in average (Terashima et al. 1997, Makishima et al. 1997). We checked the presence of similar sources, i.e. sources exhibiting hard spectra without strong absorption, in the BAT AGN catalog (Winter et al. 2009). Among the sources showing a similar hard photon-index, none is like ESO 575-G059.

References:
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