1H0419-577: A TWO-STATE SEYFERT GALAXY?

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The preliminary results of the BeppoSAX observation of the radio-quiet AGN 1H0419-577 are presented. Despite its broad line optical spectrum, the intermediate X–ray spectrum (i.e. 2–10 keV) is flatter than typically observed in Seyfert 1s and no iron line is significantly detected. Even more intriguingly, a 1992 ROSAT pointed observation suggests a dramatic ($\Delta \Gamma \simeq 1$) change in the spectral shape for $E < \sim 2$ keV. Such behavior is briefly discussed in the framework of our current understanding of Comptonization scenarios in the nuclear regions of radio–quiet AGN.

1. Introduction

1H0419-577 is a Seyfert 1.5 galaxy, according to Grupe\textsuperscript{[5]}. It was observed by Beppo-SAX within the AO1 program on September 30 1996, from 06:24:00 UT to 16:40:50 UT, for a total $\simeq 22.6$ ks exposure time in the Medium Energy Concentrator Spectrometer (MECS; 1.8–10.5 keV,\textsuperscript{[1]}) . The target was also detected in the Phoswitch Detector System (PDS,\textsuperscript{[3]}) at 2.1 $\sigma$ confidence in the 13–36 keV energy range. The Low Energy Concentrator System (LECS,\textsuperscript{[11]}) was switched off during the whole observation due to technical problems. An optical spectrum was taken at the 1.52 m ESO telescope on the same night as the Beppo-SAX observation. It displays “broad” line components (e.g. the $<FWHM_{H\beta}> = 1440$ km s$^{-1}$, and $H\beta$ can be split into broad ($FWHM \simeq 3500$ km s$^{-1}$) and narrow ($FWHM \simeq 3560$ km s$^{-1}$) components. This confirms the Seyfert 1 nature of this object.

In this paper errors are quoted at 90\% level of confidence and energies are in the source rest frame ($q_0 = 0.5$ and $H_0 = 75$ km s$^{-1}$ Mpc are assumed). Hereafter $\Gamma_{\text{hard}}$ ($\Gamma_{\text{soft}}$) indicates the photon index of a power-law above (below) $E \simeq 3$ keV.

2. The X–ray spectrum

The 1.8–45 keV spectrum is well represented by a flat (photon index $\Gamma_{3–10\text{ keV}} \simeq 1.5$) power–law with photo-electric Galactic absorption ($N_H = 2 \times 10^{20}$ cm$^{-2}$\textsuperscript{[3]}), $\chi^2 = 130.6/153$ d.o.f., see Fig.\textsuperscript{[1]}. A spectral steepening is marginally required for $E \lesssim 3$ keV ($\Gamma_{\text{soft}} - \Gamma_{\text{hard}} \sim 0.3$): $\Delta \chi^2$ for a broken (double) power–law = 2.6 (4.1) in comparison to the simple power-law. An iron line is not required either, the 90\% confidence level upper limit on the equivalent width (EW) of a 6.4 (6.7) keV narrow (i.e. intrinsic Gaussian dispersion held fixed to 0) line being 100 (170) eV. Neither a Compton reflection component nor broadening of the iron line are statistically required by the data. A summary of the best–fit parameters is shown in Table\textsuperscript{[1]}. Such properties are rather extreme among the Seyfert 1 galaxies observed in X–rays (Fig.\textsuperscript{[2]}).

These results are compared with those obtained from a ROSAT/PSPC observation of the same target, performed more than 4 years earlier (see Table\textsuperscript{[3]}). The best–fit model requires
PSPC spectrum, with \( \Gamma \) law component is assumed to be present in the soft excess has been investigated; if a power-law is used to fit the latter data. The maximum amplitude of the systemic error on the spectral index due to ROSAT/PSPC calibration (\( \sim 0.2 \)) according to \[9\] and \[13\]) cannot account for the observed difference.

The explanation of such a difference in terms of a soft excess has been investigated; if a power-law component is assumed to be present in the PSPC spectrum, with \( \Gamma_{\text{hard}} \equiv 1.55 \) and the normalization is free to vary, the data require: a) either a very steep soft power-law component (\( \Gamma_{\text{soft}} \approx 2.9 \), without any variation of the medium/hard X-ray spectrum; b) or a broad (i.e. multi-temperature) thermal component superimposed on the hard power-law, whose normalization decreased by a factor \( \sim 2 \). However, these models are statistically worse at \( \chi^2 \geq 99.997\% \) level than models where the medium/hard X-ray photon index is allowed to vary; moreover a 1995 ASCA observation of the same target did not detect any strong soft excess below energies \( E \approx 1 \text{ keV} \), despite the fact that the 2–10 keV spectrum is similarly flat as that measured by Beppo-SAX (Marshall et al., 1998, in preparation). Although the hypothesis of a variable soft excess cannot be completely ruled out, the above results suggest that the observed difference between 1992 PSPC and 1996 Beppo-SAX spectra is due to a “true” change of the Comptonized medium/hard X-ray spectrum (see also the Spec-

### Table 1
Beppo-SAX observation best-fit parameters

| Model       | \( \Gamma_{\text{hard}} \) | \( \Gamma_{\text{soft}} \) | \( E_{\text{break}} \) (keV) | \( N_{\text{soft}}/N_{\text{hard}} \) | \( \chi^2/\text{d.o.f.} \) |
|-------------|-----------------------------|-----------------------------|-------------------------------|---------------------------------|-----------------------------|
| PO          | 1.61 ± 0.06                 | ...                         | ...                           | ...                             | 130.6/153                   |
| BKNPO       | 1.56 ± 0.10                 | 1.8 ± 0.4                   | 3.0 ± 1.0                     | ...                             | 128.0/151                   |
| PO+PO       | 1.55 ± 0.09                 | 7\( ^\dagger \)              | ...                           | 3.7\( ^\dagger \)                         | 126.5/150                   |

\( ^\dagger \) unconstrained

\( ^\dagger \) fixed

Photodetector absorption from cold material with \( N_H = N_{H \text{Gal}} = 2 \times 10^{20} \text{ cm}^{-2} \) was added to all the above models.

PO=power-law, BKNPO=broken power-law, GA=Gaussian line, PEXRAV=power-law+Compton reflection

### Table 2
ROSAT observation best-fit parameters

| Model       | \( \Gamma_{\text{soft}} \) | \( E \) (keV) | \( \sigma \) (eV) | \( \Gamma_{\text{ss}} \) | \( E_{\text{break}} \) or \( T \) (eV) | \( \chi^2/\text{d.o.f.} \) |
|-------------|-----------------------------|---------------|------------------|--------------------------|-------------------------------|-----------------------------|
| BB          | ...                         | ...           | ...              | ...                      | 101 ± 1                        | 2901/151                     |
| DISKBB      | ...                         | ...           | ...              | ...                      | 142 ± 1                        | 1916/153                     |
| PO          | 2.77\( ^+0.03 \) –\( ^-0.02 \) | ...           | ...              | ...                      | ...                           | 172.7/151                    |
| ED*PO       | 2.75 ± 0.06                 | 0.67 ± 0.08   | 0.32\( ^+0.08 \) –\( ^-0.14 \) | ...                      | ...                           | 157.2/149                    |
| PO+GA       | 2.83\( ^+0.05 \) –\( ^-0.07 \) | 1.56\( ^+0.23 \) –\( ^-0.13 \) | 80 ± 40            | ...                      | ...                           | 162.7/149                    |
| BKNPO       | 2.58\( ^+0.14 \) –\( ^-0.24 \) | ...           | ...              | 2.9\( ^+0.16 \) –\( ^-0.11 \) | 800 ± 200                      | 158.0/149                    |
| PO+BB       | 2.59 ± 0.09                 | ...           | ...              | ...                      | 60\( ^+10 \) –\( ^-13 \)      | 159.2/149                    |

PO=power-law, ED=absorption edge, GA=Gaussian line, BKNPO=broken power-law, BB=blackbody, d.o.f. = degrees of freedom

\( \Gamma_{\text{PSPC}} – \Gamma_{\text{MECS}} \approx 0.7 \pm 1.3 \), see Fig. [3]. We stress that the PSPC spectral index is inconsistent with that measured by the MECS even if a broken power-law is used to fit the latter data. The maximum amplitude of the systemic error on the spectral index due to ROSAT/PSPC calibration (\( \sim 0.2 \)) according to \[9\] and \[13\]) cannot account for the entire observed difference.
Figure 1. Spectra (upper panel) and residuals in units of standard deviations (lower panel) when a power-law model with Galactic (i.e. $N_H = 2 \times 10^{20}$ cm$^{-2}$) absorption is fitted to the MECS/PDS data. The quoted photon spectral index and flux refer to this model. 90% Upper limits on the EWs of fluorescent iron lines are shown for the neutral and ionized cases.

Figure 2. Iron line EW vs. $\Gamma$ plot for the Seyfert 1 sample of [9]. The position of 1H0419-577 according to the Beppo-SAX observation is indicated. Dot size is proportional to 2–10 keV luminosity.

Figure 3. Unfolded ROSAT/PSPC spectrum (upper panel) and residuals in units of standard deviations (lower panel) for the best-fit models. A much steeper ($\Gamma_{soft} = 2.6 \div 2.8$) power-law component is required than in the MECS observations.

3. Variable soft X–ray spectrum: a chance to test Comptonization scenarios

$\Delta \Gamma \sim 1$ could occur: a) in a two-phase disk-corona accretion disk model [8], if the system undergoes a transition between a scattering optically thick ($\tau \sim 1$) and thin ($\tau \lesssim 0.1$) regimes [9], provided the plasma is far from being pair-dominated; b) in a viscous-less two-phase shock accretion disk model [4]), as the effect of a decrease of the accretion rate from quasi– to sub–Eddington regimes. The latter case would suggest a link between the radio–quiet AGN and the Black Hole Candidates, which are well known to display transitions between soft/high (typical energy photon indices $\alpha \simeq 1.5$) and hard/low states ($\alpha \simeq 0.3 \div 0.9$). The above data however do not resemble the archetypical example of such a central Energy Distribution in Fig. [1]. Further monitoring of the broadband X–ray spectrum of this source is needed to clarify this issue.
connection, RE1034+39 [12]. In this source the ROSAT/PSPC spectrum could be interpreted in terms of multi-temperature blackbody, suggesting that the soft state represent the occurrence of quasi-Eddington accretion rate events, in which the bulk of the emission comes from the energy release due to viscous dissipation in the disk. However, this is not the case for 1H0419-577 (cfr. the first two rows in Tab. 2). A change of the Comptonized spectrum provides a natural explanation for the relative faintness of the iron line as well, which could suffer a delayed response to the - currently still unknown - variability pattern of the underlying continuum.

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