Star clusters and black holes in galaxies across cosmic time
Proceedings IAU Symposium No. 312, 2014
Y. Meiron, S. Li, F.-K. Liu & R. Spurzem, eds.

doi:10.1017/S1743921315007504

Swift monitoring and *Suzaku* spectroscopy of the γ-ray detected narrow-line Seyfert 1 galaxy 1H 0323+342

S. Yao[1], W. Yuan[1], S. Komossa[2,1], D. Grupe[3,4], L. Fuhrmann[2] and B. Liu[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences, 20A Datun Road, Chaoyang District, Beijing, China
email: yaosu@nao.cas.cn

[2]Max-Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany

[3]Space Science Center, Morehead State University, Morehead, KY, 40351

[4]Swift Mission Operation Center, 2582 Gateway Dr. State College, PA, 16801, USA

Abstract. 1H 0323+342 is one of the rare γ-ray detected narrow-line Seyfert 1 galaxies (NLS1s), a special subset of active galactic nuclei (AGN) owing to their hybrid behavior of both NLS1s and blazars. The rarity of such kind of sources makes their properties far from being understood. We analyze simultaneous X-ray and UV/optical monitoring observations of 1H 0323+342 performed by *Swift* over $\sim$ 7 years. The UV/X-ray correlation and the broad band SED reveal that the X-ray band is dominated by the disk/corona emission during the observations. The large normalized excess variance of the X-ray variability detected with *Suzaku* suggests a relatively small black hole mass of the order of $10^7 M_\odot$, consistent with the estimation based on the broad Hβ line in the optical band.

Keywords. galaxies: active — quasars: individual (1H 0323+342) — galaxies: particular — galaxies: jets — X-rays: galaxies.

1. Introduction and observations

An interesting discovery of *Fermi*/LAT in recent years is the detection of γ-ray emission from several narrow-line Seyfert 1 galaxies, which are usually considered to be radio-quiet and occupy a very different domain than blazars in taxonomy of AGN (Abdo *et al.* 2009a,b; D'Ammando *et al.* 2012). It raises the question of whether these sources form a previously unrecognized population or the downsizing counterpart of normal blazars (Komossa *et al.* 2006; Yuan *et al.* 2008). As one of these sources, 1H 0323+342 has been identified by Zhou *et al.* (2007) to be a prototype of radio-loud NLS1s and was detected by *Fermi*/LAT (Abdo *et al.* 2009b). 1H 0323+342 was monitored by *Swift* for 80 occasions from 2006 to 2013. It was also observed with *Suzaku* during an 84 ks exposure. These observations provide a good data set to study the multi-waveband emission and physics of this object. We analyze the X-ray and UV/optical data of 1H 0323+342 to study both the temporal and broad band spectral properties at these wavebands.

2. Results and discussion

The object is variable in both the UV and X-ray bands on timescales of days to years, and we find a statistically significant correlation between the UV flux and X-ray count rates at these timescales. A cross-correlation analysis suggests a time lag close to zero between the UV and the X-ray emission, however, with X-rays tentatively leading during

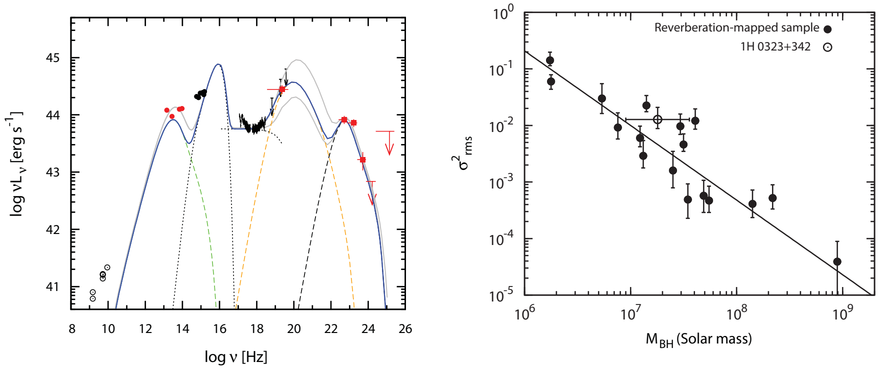

Figure 1. *Left panel*: The broad band SED of 1H 0323+342, consisting of *Swift* and *Suzaku* data used in this work. The model consist of accretion disk and corona (dotted lines) and jet (dashed line). *Right panel*: The log $M_{\rm BH}$-log $\sigma^2_{\rm rms}$ relation calibrated by the reverberation-mapped sample in Ponti *et al.* 2012 (solid line).

2010 October–November observations. This can be explained with the scenario that the UV emission is the result of reprocessing the primary X-ray emission from the accretion disk/corona. The X-ray spectrum obtained by *Suzaku* shows a soft excess below 1 keV and a power-law spectrum with a photon index of $\Gamma = 1.9$. The broad-band SED of 1H 0323+342 can be well modeled in the context of a one-zone leptonic jet model plus the accretion disk/corona, the latter is suggested to dominate the emission in the UV and X-ray bands (up to 10 keV) as observed with *Swift* and *Suzaku* (Figure 1, left panel).

Given their relatively small widths of their broad lines, the black hole masses $M_{\rm BH}$ of NLS1s are believed to be systematically lower than those of classical Seyfert 1s and quasars, resulting in high Eddington ratios (e.g., Grupe & Mathur 2004; Xu *et al.* 2012). However, there remains controversy as to whether their black hole masses are underestimated, if their broad line regions are planar and seen face on. As the X-ray below 10 keV is dominated by a disk/corona component during the *Suzaku* observation, an independent estimation of $M_{\rm BH}$ can be achieved by using the X-ray normalized excess variance $\sigma^2_{\rm rms}$ (Ponti *et al.* 2012). We find $\sigma^2_{\rm rms,2-4keV} = 12.3^{+8.1}_{-3.9} \times 10^{-3}$, which corresponds to a black hole mass of $M_{\rm BH} = 8.6^{+2.9}_{-2.7} \times 10^6 M_\odot$, using the relation in Ponti *et al.* (2012). This value is consistent with $M_{\rm BH} = 1.8 \times 10^7 M_\odot$ estimated from the broad Hβ line in Zhou *et al.* (2007) (see Figure 1, right panel). We conclude that the black hole mass is small in at least this particular γ-ray detected NLS1.

Acknowledgements

This work is supported by grants No. 11473035 & No. XDB09000000.

References

Abdo, A. A., Ackermann, M., Ajello, M., *et al.* 2009a, *ApJ*, 699, 976
—. 2009b, *ApJ*, 707, L142
D'Ammando, F., Orienti, M., Finke, J., *et al.* 2012, *MNRAS*, 426, 317
Grupe, D. & Mathur, S. 2004, *ApJL*, 606, L41
Komossa, S., Voges, W., Xu, D., *et al.* 2006, *AJ*, 132, 531
Ponti, G., Papadakis, I., Bianchi, S., *et al.* 2012, *A&A*, 542, A83
Xu, D., Komossa, S., Zhou, H., *et al.* 2012, *AJ*, 143, 83
Yuan, W., Zhou, H. Y., Komossa, S., *et al.* 2008, *ApJ*, 685, 801
Zhou, H., Wang, T., Yuan, W., *et al.* 2007, *ApJL*, 658, L13

https://doi.org/10.1017/S1743921315007504 Published online by Cambridge University Press