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The Optical–X-ray Connection in the Narrow-Line Seyfert 1 Galaxy Akn 564

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Abstract. We present the results of a 10-month long simultaneous optical and X-ray monitoring campaign on the narrow-line Seyfert 1 galaxy Akn 564. We observed rapid and large-amplitude variations in the X-ray band on a daily time-scale. These were not detected in the optical wavelengths, which showed no significant variability either on short (one day) or long (several months) time-scales. The large X-ray variations seem to vanish when the light curve is smoothed over a period of 30 days. It is hard to reconcile this behaviour with reprocessing models that predict the X-ray photons to be the major energy source for the optical continuum emission. Our results add to the growing evidence that the optical–X-ray connection in active galaxies is very complicated and perhaps that the bulk energy in those two bands originates in different regions.

1. Description

We present the results of a 10-month long simultaneous optical and X-ray monitoring campaign on the narrow-line Seyfert 1 galaxy Arakelian (Akn) 564 ($z = 0.0247$). Participating in the campaign were: the Tel-Aviv University Wise Observatory (WO), the MDM Observatory on Kitt Peak, the Crimean Astrophysical Observatory (CAO), Osservatorio Astronomico di Bologna at Loiano (Loiano), the Katzman Automatic Imaging Telescope (KAIT) at Lick Observatory and the Observatory of the Southeastern Association for Research in Astronomy (SARA). X-ray observations were carried out by *RXTE* .

During this campaign Akn 564 was observed with *RXTE* and in the optical band about twice a week for a period of six months, followed by a dense sampling period of two weeks, when the galaxy was observed twice a day.

In Figure 1 we present a mean optical spectrum of Akn 564 taken at WO during the campaign. The continuum and line measurement bins, which were used in our analysis, are marked. The optical and X-ray light curves appear in Figure 2. The vertical gap at JD=2451475 marks the beginning of the dense sampling period.

Table 1. Variability Measure ($10^{-3} \times \sigma^2_{rms}$)

Band	Sparse	Dense	All
4900Å	1.07 ± 4.22	0.65 ± 1.68	0.94 ± 2.58
Hβ	0.16 ± 2.78	0.03 ± 1.90	0.17 ± 1.83
5200Å	0.89 ± 1.97	0.37 ± 0.74	0.71 ± 1.21
6600Å	0.57 ± 0.70	0.00 ± 0.01	0.41 ± 0.48
Hα	0.02 ± 0.16	0.44 ± 1.69	0.17 ± 0.67
6900Å	0.68 ± 0.88	0.02 ± 0.04	0.52 ± 0.64
X − ray	64.40 ± 5.32	90.65 ± 57.33	77.10 ± 20.85

2. Results

Variability measures, following the description by Turner et al. (1999), were calculated for each spectral band in both the sparse and dense sampling periods as well as for the entire period and appear in table 1.

We arrive at the following conclusions:

(1). The very strong, ∼100% peak-to-peak and rapid, ∼1 day, X-ray variations that characterise NLS1 galaxies are also seen in our data for Akn 564. However, The mean X-ray flux was basically constant on time-scales larger than ∼30 days.

(2). The optical continuum and emission lines did not vary by more than ∼3% throughout the campaign. This prevented us from measuring R_{BLR} and M_{BH} for Akn 564 using reverberation mapping techniques.

(3). It is hard to reconcile the observed behaviour with models where the optical continuum emission is reprocessed X-ray radiation.

References

Turner T.J., George I.M., Nandra K., and Turcan D., 1999, ApJ, 524, 667

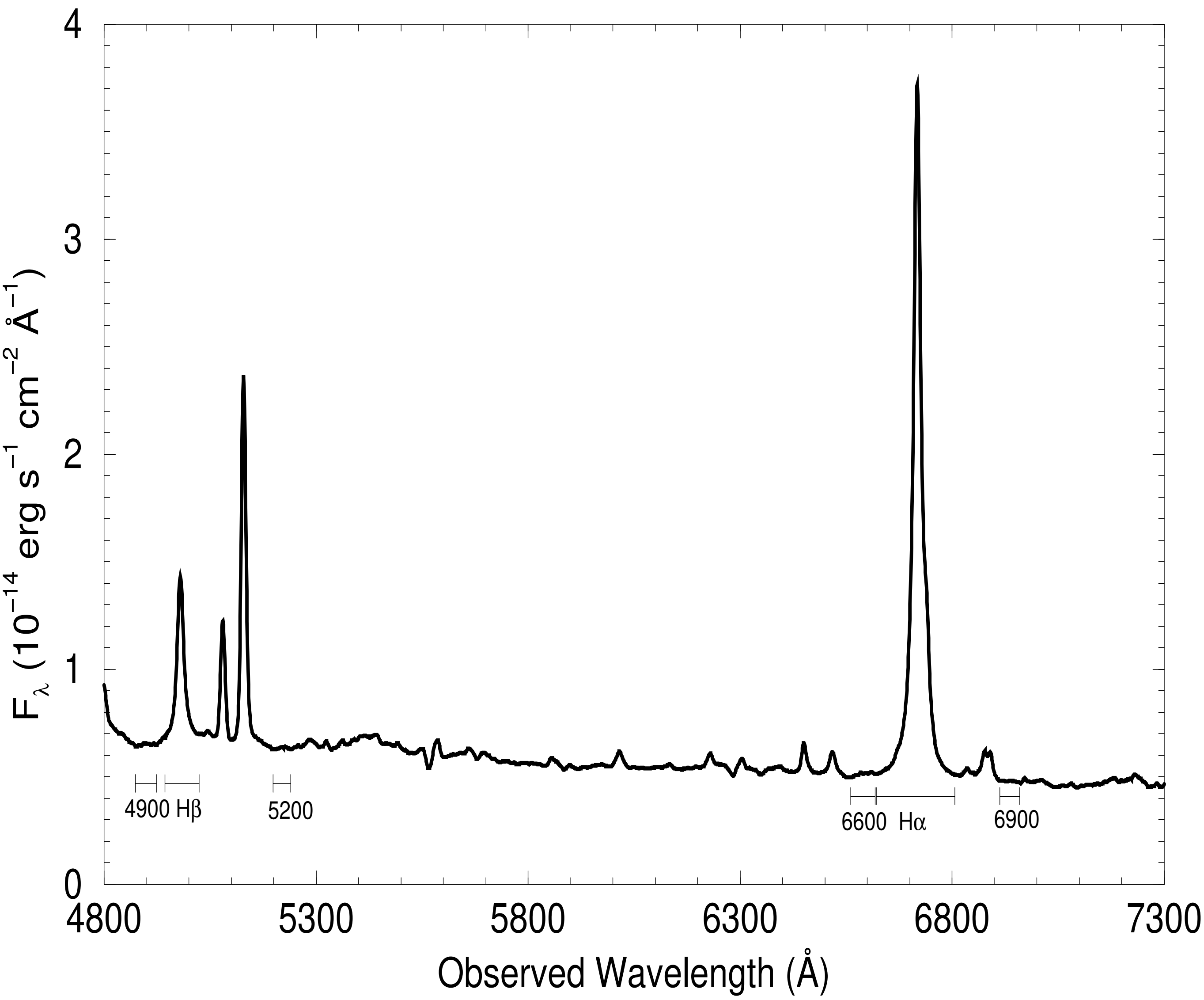

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Fig. 1. Mean spectrum of Akn 564 observed at WO. The continuum and line measurement bins are marked.

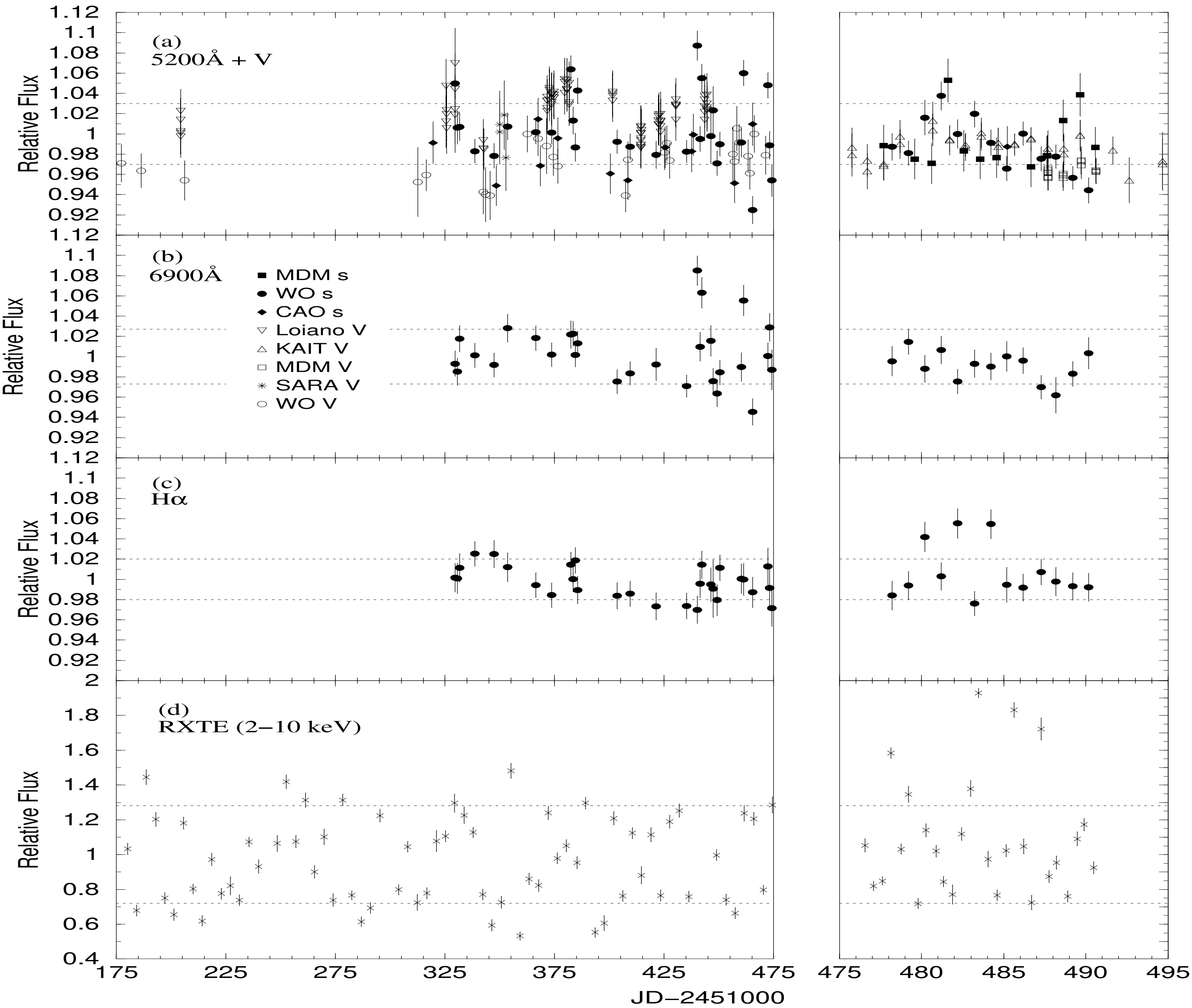

Fig. 2. Akn 564 light curves. (*a*) The continuum at the narrow 5200Å band combined with a filter V band. (*b*) The continuum at the narrow 6900Å band. (*c*) Hα and (*d*) 2-10 keV X-ray band (note the very different flux scale). Dotted horizontal lines represent $\pm\sigma$ around the mean fluxes. The legends in panel (*b*) apply to panels (*a*) and (*c*) as well. The vertical gap at JD=2451475 defines the beginning of the dense sampling (note the different temporal scale to the right of that vertical gap).