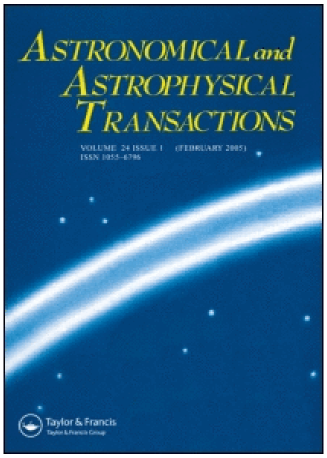

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Moving variable emission lines in the spectrum of the Seyfert galaxy NGC4151

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MOVING VARIABLE EMISSION LINES IN THE SPECTRUM OF THE SEYFERT GALAXY NGC4151

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The sharp emission lines (satellites) of variable amplitude, changing their wavelength linearly with time, have been found at the shorter wavelength wings of broad components of H_α and H_β hydrogen lines in the spectrum of the Seyfert galaxy NGC 4151 in March, 1986 and January – April, 1988.

KEY WORDS NGC 4151, emission lines, radial velocity

1 INTRODUCTION

Since 1970, spectroscopic observations of about 50 brightest Seyfert galaxies are carried out at the Astrophysical Institute using a difractional spectrograph and a three-stage image tube attached to the 70 cm reflector. The aim of this work is to study variations of galactic spectra. The high quality treatment of spectrograms became possible only in 1992 when we introduced a microdensitometer AMD1.

Because of increasing attention to bright and highly variable galaxy NGC 4151, we began to measure the spectrograms of this object. As result of this treatment, emission features of complex structure changing their amplitudes and radial velocities have been discovered in the spectrum of NGC 4151.

2 THE RESULTS OF OBSERVATIONS IN JANUARY - APRIL 1988

Figures 1a, b show portions of two spectrograms of NGC 4151 taken on 16.04.88 in the H_α+[NII] blend practically simultaneously (exposure time: 4 and 8 minutes). After the first exposure had been finished, the nucleus of the galaxy was shifted along the slit of the spectrograph in order to put the image of the spectrum on the other cathode part of the image tube to exclude its possible defects.

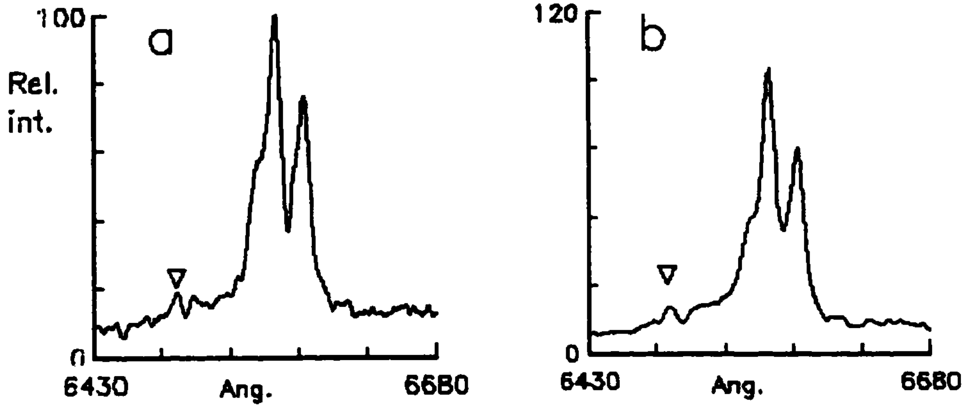

Figure 1 Fractions of spectra of the nucleus of NGC 4151 observed on April 16, 1988. The triangle shows the satellite.

The feature marked with a triangle in Figure 1 consists of a sharp emission component terminated at the red side with a sharp absorption of comparable intensity. It is possible that really we observe a broad emission (its width being about twice larger than that seen on the spectrogram) and a sharp absorption obscuring its centre. We consider that this satellite is visible at 4–5σ above the level of noise.

The radial velocities of maxima measured relative the centre of H_α are equal to $U_r = -3300$ km/s for Figure 1a, b.

The features of a similar form are well defined on the spectrograms taken on 23.02.88, their radial velocity U_r is equal to −4660 km/s.

We have examined all other spectrograms obtained between January and April, 1988, to search for similar emissions. It appears that similar features but with smaller amplitude were surely registered on 16.03.88. For two spectrograms obtained with exposure time $T_{\rm exp} = 6$ and 4 min, $U_r = -4270 \pm 70$ km/s.

There is an emission satellite on the spectrograms taken in the H_β line region on 13.01.88 ($T_{\rm exp} = 4$ and 2 min, $U_r = -5300 \pm 100$ km/s). Their amplitudes correspond to 2–3σ above the noise level. The linear relation between U_r and the moment of observation persists in all described cases (see Figure 2).

The presence of similar emission features in the profiles of H_α and H_β allows to suppose that all these satellites are radiated by the same source – an object consisting of ionized hydrogen and moving relative the galactic nucleus.

3 THE RESULTS OF OBSERVATIONS IN MARCH 1986

Three spectrograms, shown in Figure 3a, b, c, have been obtained in the H_β line region on 09.03.86. (During these observations, we shifted the image of the nucleus along the slit of the spectrograph before every exposition). The satellite similar to

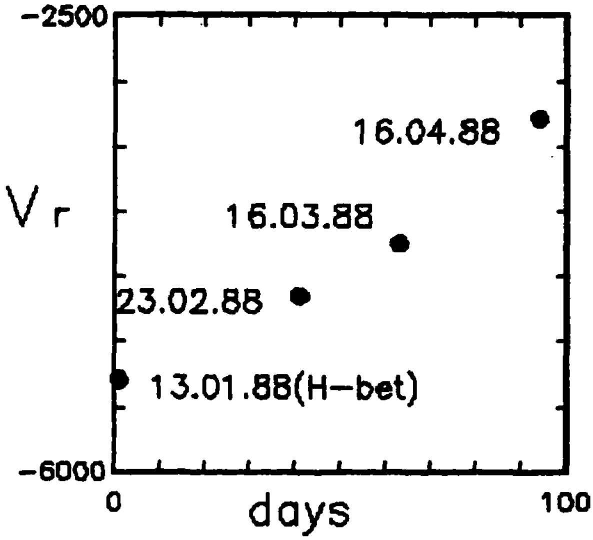

Figure 2 U_r of the satellite observed in Alma-Ata (Jan.-Apr. 1988) as a function of time.

that described above is clearly seen on all three spectrograms ($T_{\rm exp}$ = 4, 2 and 1 min).

Approximately on these dates NGC 4151 was observed with the 6-meter telescope of the Special Astrophysical Observatory (SAO) (Bochkarev *et al.*, 1989). Eighteen original spectrograms are presented in Figure 1 of the cited paper. On eight of them, in the range of U_r values from –800 km/s up to –1800 km/s, one can easily notice an emission-absorption satellite similar to the type discussed above. This feature was certainly not visible in April 1986 because it overlapped the central profile of H_β (see Figure 1 of Bochkarev *et al.*). We have measured U_r values of the satellite directly from Figure 1 using the wavelength scale of Bochkarev *et al.* (1989) and plotted U_r vs time (Figure 4). The sign "?" means that the feature was not seen on this date.

We have two spectrograms obtained on 07.03.86 in the H_β line region; it is possible that the same satellite with $U_r = -2265 \pm 35$ km/s is present on these spectrograms but its amplitudes are on the level of noise. Thus, we consider these results quite uncertain. The errors of points corresponding to the SAO data are determined from the width of lines in Figure 1 in the paper by Bochkarev *et al.*

DISCUSSION

Several questions arise in connection with the presented results:

1. Why this phenomenon was not found up to now during observations with large and very large telescopes and from space-borne observatories which used modern CCD receivers? It is especially strange in view of great attention to this galaxy.

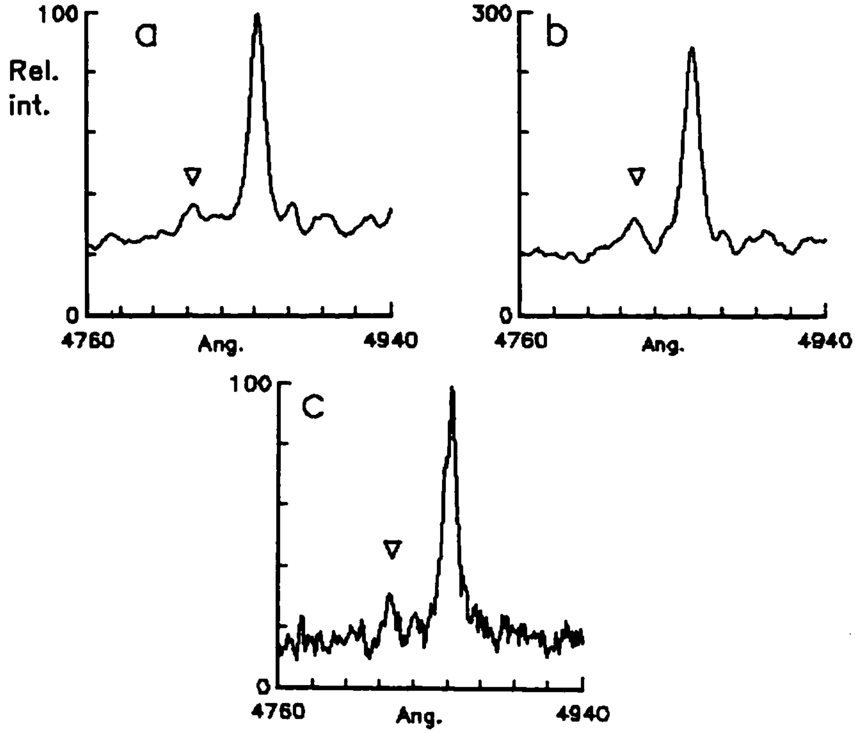

Figure 3 Fractions of spectra of the nucleus of NGC 4151 observed on March 9, 1986. The triangle shows satellite.

There are three possible reasons for it:

(a) The spectral resolution of most spectral observations of Sy galaxies is, as a rule, worse than 5Å. Therefore, it is clear that if the distance between maxima of the emission and the absorption is about 5Å, these details would not be seen on spectrograms with resolution less than 5Å. We can achieve the spectral resolution as high as 2.5Å (for bright objects).

(b) Satellites are clearly seen during only a rather short time. On the other hand, high – quality observations are carried out rarely. Thus, a probability of coincidence of the moment of observations with the maximum of the satellite brightness is very low.

For example, these satellites have been seen only during three nights from 60, i.e. successful cases are about 5%.

(c) During 1991 and later on, to 1994, when quantity and quality of CCD receivers highly increased, the nucleus of NGC 4151 entered the more active period

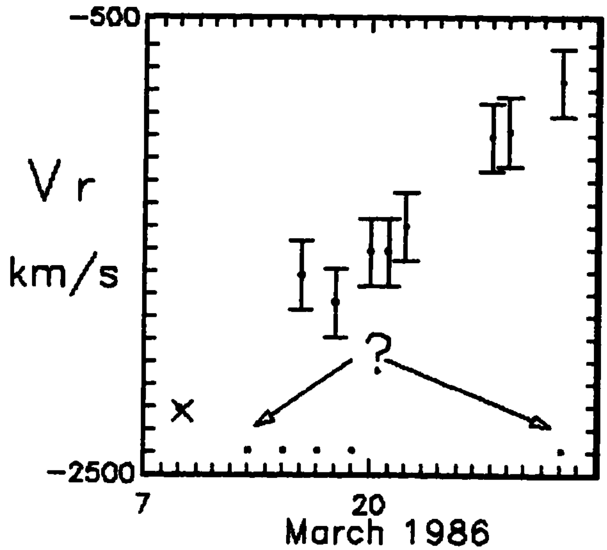

Figure 4 U_r **of the satellite observed in SAO (March 1988) and in Alma-Ata (9.03.86) as a function of time.**

compared to 1986–1988. Thus, satellites could become invisible or very weak in these new conditions.

2. What kind of information may be derived from the study of the satellites' behaviour, of course if they really exist and change with time?

Figures 2 and 4 show the time dependences of the radial velocity projection of some clouds on the line-of-sight. The linear dependence shows that we have either linear motion with slow deceleration along the jet or a small part of a Keplerian orbit. Systematic observations with high spectral resolution can answer this question. If the brightness of satellites is really variable, simultaneous detection of the brightness of the continuum and satellites in several points of the orbit can give the information about absolute distance of the satellite from the nucleus, inclination of its orbit to the line-of-sight and other useful information about the nucleus and the space around it.

It should be noted that the energy in the emission part of the satellite equals to about 2×10^{-13} ergs s^{-1} cm^{-2} (using data from Maoz *et al.*, 1991), or 2% of that in the H_α+[NII] blend.

CONCLUSIONS

It is possible that high activity of the NGC 4151 nucleus observed during the recent years requires, in order to notice the satellite, higher spectrophotometric accuracy (of the order of 1%) with spectral resolution of 2–2.5Å.

There is reason to look for similar phenomena in other extragalactic objects with active nuclei.

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