course, the high temperature of the white dwarf also easily explains the X-rays from GQ Muscae. Unfortunately, after the termination of the EXOSAT mission, for several years no X-ray satellite sensitive to soft X-ray radiation has been available for some time and none will be available until the launch of ROSAT. Only very little observational material on the late phases of the classical nova outburst is available yet. Many crucial questions remain: How long does the hydrogen shell burning really last? When does a nova turn off? In the case of GQ Muscae, we have demonstrated how long-term observations of novae in the optical spectral range can help to improve this situation. The observations appear to constitute an important verification of the TNR model of the classical nova outburst.

Violent Activity in the Bright Quasar 3C 273

T. J.-L. COURVOISIER, Observatoire de Genève, Sauverny, Switzerland

Observations of the optical variability in the bright quasar 3C 273 date from long before this source has been found to be a quasar. Almost a century of (mostly photographic) data are available (Angione and Smith, 1985) and display variations on many timescales longer than ~10 days. In more recent years, a programme of multi-frequency observations of the quasar from the radio domain to the X-rays has been conducted. The first results of this programme have been described in the *Messenger* No. 45 (September 1986). In summary, we found variations by a factor ~2 in most observable spectral domains. The typical variability timescale was of the order of one month. The different components of the source varied at different epochs, showing little correlation between them. This complex variability pattern allowed to identify distinct components and showed that most of them must be emitted in regions not larger than about one light-month.

This multi-waveband campaign of observations started in late 1983 and has been pursued during each observing season (December to July) since then. Until now, different types of variability behaviour have been observed each year. Figure 1 illustrates this by showing the V band flux as a function of time since January 1985, when the Swiss telescope on La Silla joined in the programme with regular and precise photometric measurements. A slow flux increase can be seen in 1985, followed by a year of very small variations in 1986. During the observing season which started in December 1986, the UV flux (measured with IUE) decreased by ~40%, the decrease was much less important at longer wavelengths but can still be seen in the figure. The most striking feature of the figure, however, is the change of the behaviour of 3C 273 in February 1988. At this time, which is well within the observing season, the source changed from a state characterized by relatively slow changes to a state of rapid and recurrent flares. The characteristic times were then not of the order of an month as during the previous years, but rather of the order of a day. This violent activity in 3C 273 came at a very appropriate time, when our collaboration was well established and could react rapidly to the observed changes. We were thus able to observe very frequently, even daily for part of the time, in the optical and infrared domains. The observations were performed at the ESO 1-m telescope, the ESO/MPI 2.2-m telescope, the 70-cm Swiss telescope on La Silla, the UK infrared telescope (UKIRT) in Hawaii and with the mm telescope SEST at ESO and JCMT in Hawaii. The results of these observations have been published (Courvoisier et al. 1988). Even with the temporal and spectral sampling that we were able to obtain during the flares, the flux variations were so fast that we could not resolve them satisfactorily.

The period of violent activity lasted from February to April 1988. During this interval, we observed 5 optical maxima separated on average by ~15 days, although 2 of the maxima are separated by 2 days only (Fig. 2). The amplitude of these maxima is of about 30%. The fastest change we observed was a flux decrease of ~15% in 24 hours. This flux decrease corresponds to a change in luminosity in the source of about $-6 \cdot 10^{40}$ erg s^{-2} or to the switching off of ~10 million suns per second for 24 hours (assuming a distance to 3C 273 based on a cosmological model with $H_0 = 50$ km s^{-1} Mpc^{-1} and a source emitting isotropically).

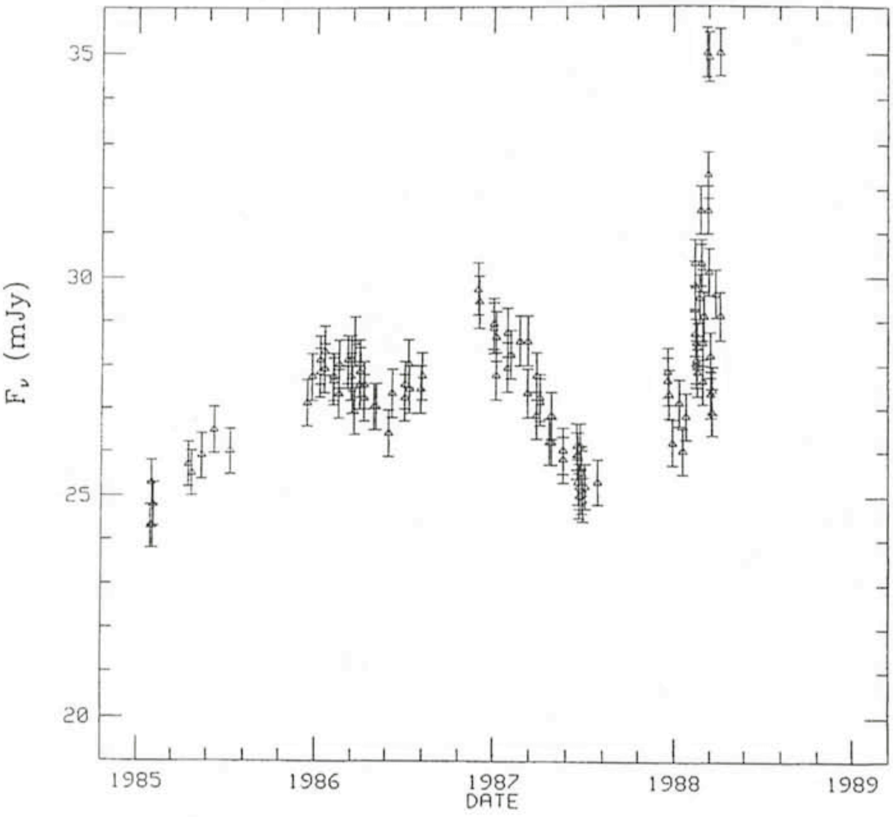

Figure 1: *The V-band light curve obtained with the Swiss telescope on La Silla since early 1985.*

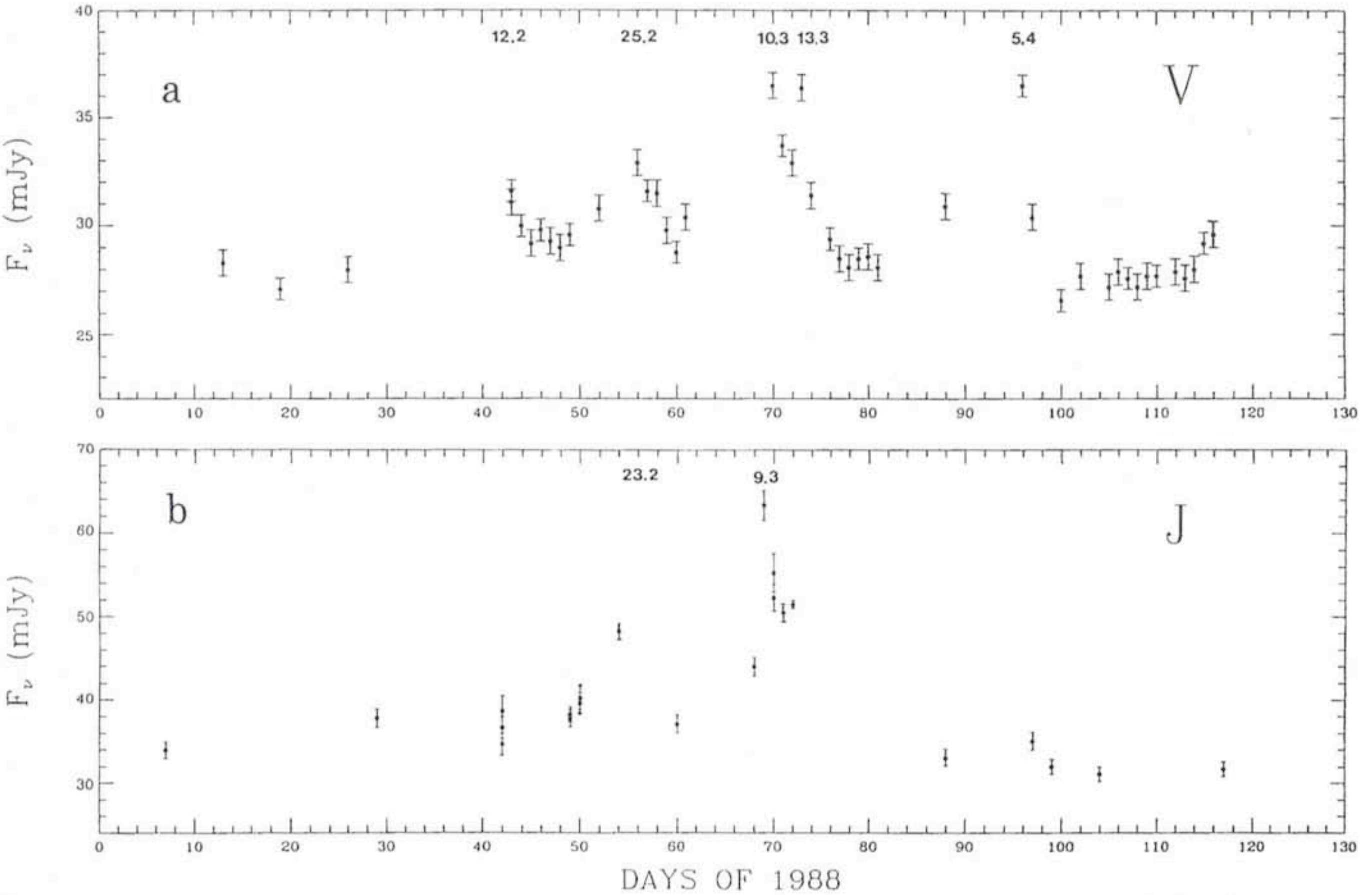

Figure 2: *The V (a) and J (b) observed fluxes during the 1988 flares of 3C 273. The dates of the observed maxima are indicated.*

In the infrared domain, we also observed repeated flares, but only 2 maxima have been seen (Fig. 2), coincident with two of the visible maxima. The amplitude of the maxima with respect to the "quiescent" emission measured the previous year was larger than in the visible and amounted to roughly a factor 2. The fastest change in the observed infrared flux was by ~40% in 24 hours, it was a flux increase rather than a decrease. This change in the infrared flux corresponds to a change in the luminosity of ~+6·10^{40} erg s^{-2}, i.e. to the switching on of about 10 million suns every second for 24 hours. It can be seen on Figure 2 that the fastest measured flux variations need not be the fastest source variations, because the sampling of the light curve is not sufficient to resolve the variability.

Infrared and optical daily observations around the March 10th flare allowed to follow the spectral evolution around this date. In general it was seen that the spectral energy distribution became steeper as the flux decreased. This type of behaviour is characteristic of synchrotron emission, the radiation of relativistic electrons in a magnetic field. The steepening of the energy distribution happens because the electrons emitting the higher frequency photons loose their energy faster than the others. The observation of a decay time for the flare (about 2 days) allowed the estimation of the magnetic field in the emission region. This was found to be ~0.7 Gauss, about the same field as is existing on the Earth. This estimate of the magnetic field is important as it is free of the large uncertainties normally linked with measurements based on the overall shape of the synchrotron emission.

The polarization of the incoming flux was also observed daily for a week in late February. The polarization was found to be about ten times more important than normally in 3C 273, and to vary significantly from day to day.

The observed properties of the 3C 273 flare component as described here are very similar to the typical behaviour of another type of active galactic nuclei: the BL Lac objects. These latter objects are well known for their rapid variations and for the night to night changes in their (high) polarization. Their emission is also usually ascribed to synchrotron emission. BL Lacs and quasars differ however in many respects: BL Lacs have no prominent "blue bump", which dominates the optical UV emission of quasars (and of 3C 273 in particular), BL Lacs do not show emission lines, which are also a prominent feature of quasars (and 3C 273), and BL Lacs usually are highly polarized, whereas 3C 273 in its normal state has a very low level of polarization. Our observations show therefore that the same processes can be at work occasionally in quasars as are normal in BL Lacs, although both are very different types of sources. We also know that the BL Lac like behaviour of quasars is a relatively rare event, because we observed it only once in several years of monitoring.

One of the optical flares, the last on April 5, seems to have had quite different properties, its maximum amplitude was not in the V band but at higher frequencies, further in the blue. This indicates that it was not an infrared flare, as is also suggested by the appearance of the infrared light curve at this epoch. If interpreted in terms of synchrotron emission, this last event must have been caused by a very peculiar population of electrons, in which the more energetic electrons are more numerous than the less energetic ones. This type of distribution is very unusal. Which other emission process could explain the energy distribution and the very fast variations is not clear yet.

Very fast variability is often a (distance independent) indication of relativistic motion in the source. The argument is that the high energy electrons in a synchrotron source also scatter the infrared synchrotron photons and give them some of their energy, shifting them thus to the X-ray domain. This combined process is called synchrotron self-Compton emission and is a function of the source size: smaller sources have a larger self-Compton component compared to the synchrotron component. Sources for which the luminosity and size are such that the brightness temperature is in excess of $\sim 10^{12}$ K should emit much more in the X-rays than in the synchrotron branch. This is known as the Compton catastrophe, and is not observed in active galactic nuclei. In quasars, the source size is estimated using the variability timescale of the source, and if the brightness temperature calculated with the infrared or radio flux and variability timescale is in excess of the Compton limit, one can deduce that the true source luminosity is smaller than what can be calculated from the observed flux using an isotropic emission geometry. The simplest anisotropy is that the source is moving relativistically towards the observer, thus boosting the synchrotron flux in the direction of the observer.

In 3C 273, the observations described here imply a brightness temperature well below the Compton limit. However, we have some observations at longer wavelength close to the February infrared maximum, and these observations indicate that the flux continues to rise towards the longer wavelengths, so that, if the spectrum of the March 10 event is similar to the February 25 maximum or if rapid variability also occurred around February 25 (both are probable but neither can be established with our spectral and temporal sampling), then the brightness temperature is in excess of the Compton limit. Further evidence along these lines comes from the mm observations performed this year: Preliminary results (Robson et al., in preparation) indicate very rapid variations and therefore extremely high brightness temperatures, well in excess of the Compton limit. It is therefore possible that the source of the flares is moving at relativistic speeds towards the observer.

The evidence for a brightness temperature in the flares of 3C 273 well in excess of the Compton limit, and thus of relativistic bulk motion of the flare source, is important as it suggests that the emission region is associated with the superluminal jet observed with VLBI (Cohen et al. 1987). This jet is highly structured with new knots appearing at more or less regular intervals and moving away from the source at very high velocities. The flares could then well be the first signs of a new knot appearing in the jet.

The very rapid variations observed during the flare of the bright quasar 3C 273 cast some doubt on the observations of previous flares in this source. It is clear that observations with a less dense temporal sampling would have missed most of the structure we observed and led to quite different conclusions. Also the very structured nature of the flares may be somewhat discouraging for observers, as it indicates that daily observations at least are required to study this type of events. However, this structure also indicates that there is a wealth of information to be obtained on the source geometry, on the acceleration of electrons to relativistic energies and on emission processes. This information will certainly prove important to constrain detailed models of the emission region. Future observations will have to find the relationships between the flaring activitiy and the other properties of the quasar and try to find what triggers the beginning of a flare, and so maybe help understand the nature of the superluminal jet.

We could obtain a dense spectral and temporal sampling of the 3C 273 flares only with the help and assistance of many rapid reactions to our requests at ESO and in Hawaii.

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UM 425: a New Gravitational Lens Candidate

G. MEYLAN, ESO, and S. DJORGOVSKI, CalTech, Pasadena, USA

I. Introduction

Since the first theoretical discussions more than 50 years ago on the phenomenon of light rays bent by intervening mass in the universe (Eddington 1920, Einstein 1936, Zwicky 1937 a, b), gravitational lensing has steadily grown to become one of the most active fields of research in extragalactic astronomy today. There are numerous theoretical investigations (Refsdal 1964, 1966, Turner et al. 1984, Blandford and Narayan 1986, Blandford and Kochanek 1987 a, b), but the observations of good gravitational lens candidates are still rare. It is only during the last decade that a few quasar systems have been found in reasonable agreement with the gravitational lensing interpretation, viz., 0957+561 (Walsh et al. 1979), 1115+080 (Weymann et al. 1980), 2016+112 (Lawrence et al. 1983), 2237+030 (Huchra et al. 1985), 0142−100 (Surdej et al. 1987), and 1413+117 (Magain et al. 1988). In other possible cases, e.g., 2345+007 (Weedman et al. 1982), and 1635+267 (Djorgovski and Spinrad 1984), there has so far been no detection of lensing galaxies, and thus they should possibly be considered as genuine pairs of interacting quasars, similar to the probable binary quasar PKS 1145−071 (Djorgovski et al. 1987). Recently, so-called giant luminous arcs have been observed in a few clusters of galaxies. They are interpreted as segments of Einstein rings, created because of an almost perfect alignment of the lensing cluster potential well with the lensed background object (Soucail et al. 1988, Lynds and Petrosian 1988). Blandford and Kochanek (1987) provide the most comprehensive and updated review on these subjects.

To improve our knowledge on the phenomenon of gravitational lensing, we are conducting an optical imaging survey for lensed quasars, with a spectroscopic follow-up for the promising cases. The quasar UM 425 = QSO 1120+019 (MacAlpine and Williams 1981) is one of the objects selected as potential lens candidates on the basis of two criteria: a large apparent optical luminosity ($M_V \leq -28$), and a relatively large redshift ($z \geq 1.5$). These simple criteria, chosen to reflect possible gravitational magnification (luminosity) and to provide a large intercept length (redshift), increase the a priori probability that a quasar selected from a magnitude-limited sample is lensed. The efficiency of such simple criteria is demonstrated by the present case, by a few other candidates from our survey which are still awaiting confirmation,