A NEW VERY INTERESTING PAIR OF QUASARS : Q0107-025 A and B

(X)
J. SURDEJ, J.-P. SWINGS, A. HENRY
Institut d'Astrophysique, Université de Liège, Belgium

H. ARP
Mount Wilson and Las Campanas Observatories,
Carnegie Institution of Washington

A. KRUSZEWSKI
Warsaw University Observatory and
European Southern Observatory (Garching bei München)

H. PEDERSEN
European Southern Observatory (La Silla)

Paper n° 48

Abstract: A search for ultraviolet-excess objects in a field centred around NGC 450 has revealed the presence of two quasar-candidates ($m_v \sim 18.2$ and 17.4 mag.) fairly near one another (separation of 77 arcsec.). Preliminary spectroscopy with the Palomar 5 m telescope shows that these objects are indeed two quasars (Q0107-025 A and B) having very similar spectra and redshifts ($z \sim 0.96$), suggesting a new possible case of twin quasars or of a gravitational lens. Although the analysis (to be published elsewhere) of additional spectroscopic data collected with the ESO 3.6 m telescope rather favours the first interpretation, higher resolution data are still necessary before rejecting definitely the second possibility. Deep multi-color CCD frames obtained with the Danish 1.5 m telescope clearly show that a group (or cluster ?) of faint galaxies is detected in the vicinity of the two quasars.

1. Associations of quasar-candidates

A search for ultraviolet-excess objects in a large field area (~ 25 deg^2) around NGC 450 (Swings et al., 1983, these proceedings) has revealed the presence of about 14 tight groups of quasar-candidates : such associations typically include 2.6 candidates with a mean separation between the two nearest objects of roughly 5.2 arcmin. The smallest and largest separations are 27 arcsec. and 8 arcmin., respectively. We obtained spectroscopic data for QSO-candidates belonging to 12 of these 14 groups: 9 associations were found to contain at least two quasars.

One of these associations turned out to be very interesting: it contains five ultraviolet-excess objects -labelled 8, 9, 10, 11 and 12 in the original survey (see Fig. 1)- which were observed to be all quasars (see Table 1). Among these, quasars 10 (Q0107-025 A, $m_v \sim 18.2$ mag.) and 9 (Q0107-025 B, $m_v \sim 17.4$ mag.) separated by 77 arcsec. (see Table 2) form a very interesting pair (cf. Table 1, $\Delta z < 0.01$).

Results on the other 13 associations will be reported elsewhere.

X Chercheur Qualifié au Fonds National de la Recherche Scientifique (Belgium)

Table 1 : The tight group of five quasars (see Fig. 1)

QSO n°	Redshift
8	0.73
9	0.95
10	0.96
11	1.89
12	1.24

Table 2 : Accurate positions for Q0107-025 A and B

	Standard iden.	R.A.(1950.0)	Dec.(1950.0)
-->	Q0107-025 B	$01^h07^m43.37^s$	$-02°34'48''.2$
-->	Q0107-025 A	01 07 40.28	-02 35 50.0
		$\pm$ 0.02	$\pm$ 0.3

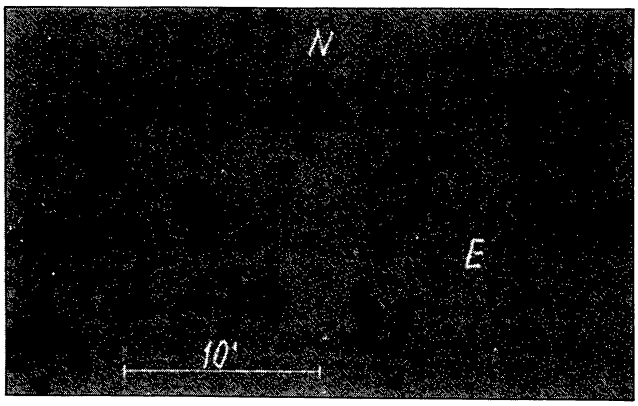

Figure 1 : Small area of the original dual image (U/B) plate on which the QSO-candidates 8, 9, 10, 11 and 12 were identified.

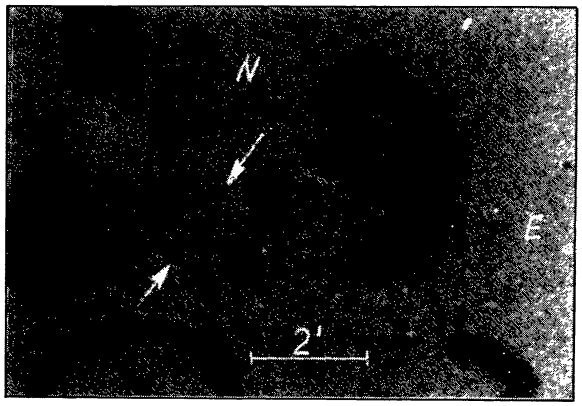

Figure 2 : The ultraviolet-excess of the QSO-candidates 9 and 10 is very conspicuous on this enlarged picture. Their U and B images are oriented west- and east-ward, respectively.

2. Spectroscopic observations of Q0107-025 A and B

Spectroscopic observations obtained in october, 1981 with the Palomar 5 m telescope (image counting spectrograph) show that these objects are indeed two quasars (Q0107-025 A and B) having very similar spectra and redshifts, suggesting a new possible case of twin quasars or of a gravitational lens (see Figs. 3 and 4). On the basis of the C III] emission line observed at $\lambda \sim$ 3730 Å, the redshifts of the two quasars are found to be z = 0.96 and z = 0.95 $\pm$ 0.01, respectively. Mg II is also detected as a very broad emission line at $\lambda \sim$ 5470 Å. The ratio of the two QSO's spectra is illustrated in Fig. 5. The bad weather conditions (clouds plus poor seeing) prevailing during the observations preclude us from detecting any meaningful difference between the two spectra (except perhaps for a slight shift in wavelength). From this set of observations, we can also state that Q0107-025 A was roughly $\pm$ 0.75 mag. fainter (in the equivalent B band) than Q0107-025 B in october, 1981.

Q0107-025 A and B have subsequently been observed on 18 and 19 september, 1982, using the Image Dissector Scanner (IDS) attached behind a Boller and Chivens spectrograph at the f/8 Cassegrain focus of the ESO 3.6 m telescope. Whereas a detailed analysis of these observations will be reported elsewhere, a confirmation of the reality of the redshift difference ($\Delta z \sim 0.004$) between Q0107-025 A and B, and the great resemblance between their two spectra are to be stressed here.

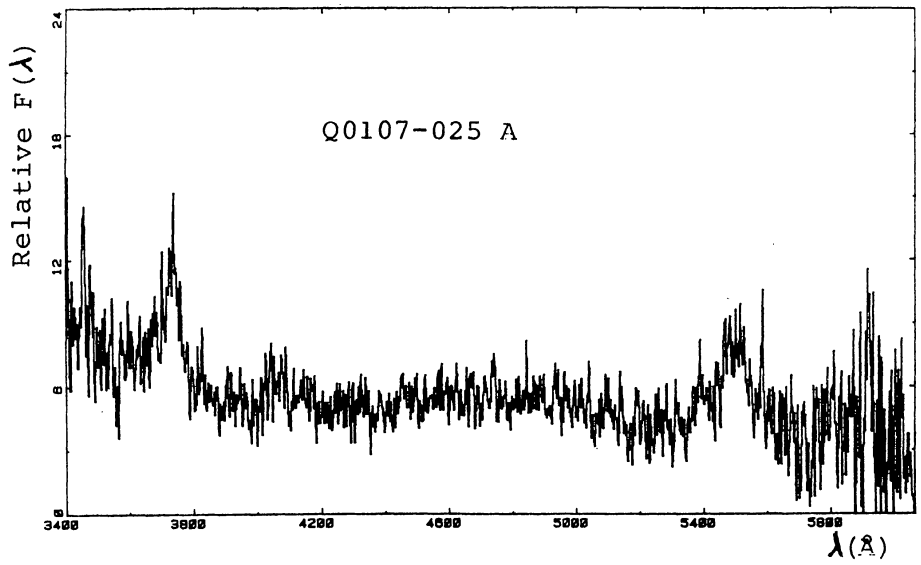

Figure 3 :

Spectrum of the QSO 0107-025 A obtained with an image counting spectrograph attached to the Palomar 5 m telescope.

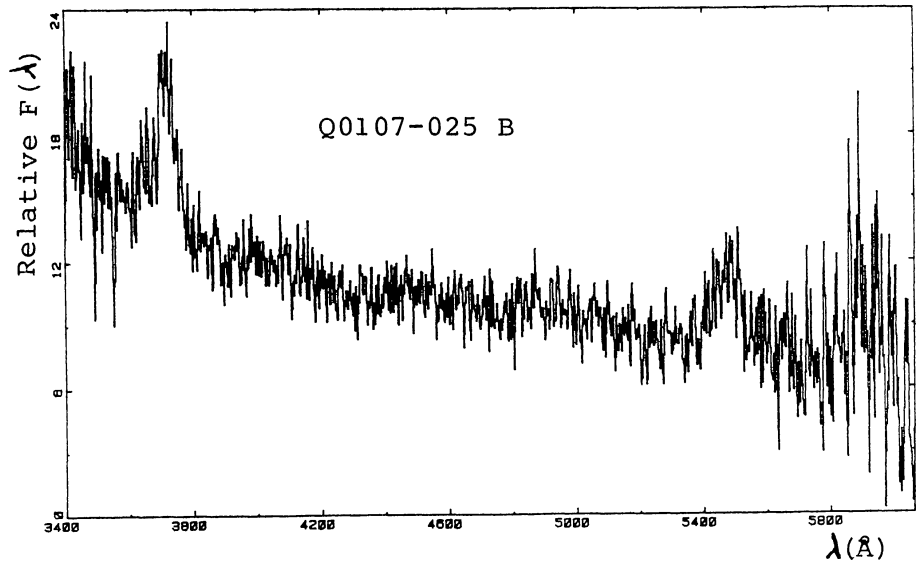

Figure 4 :

Spectrum of the QSO 0107-025 B obtained with an image counting spectrograph attached to the Palomar 5 m telescope.

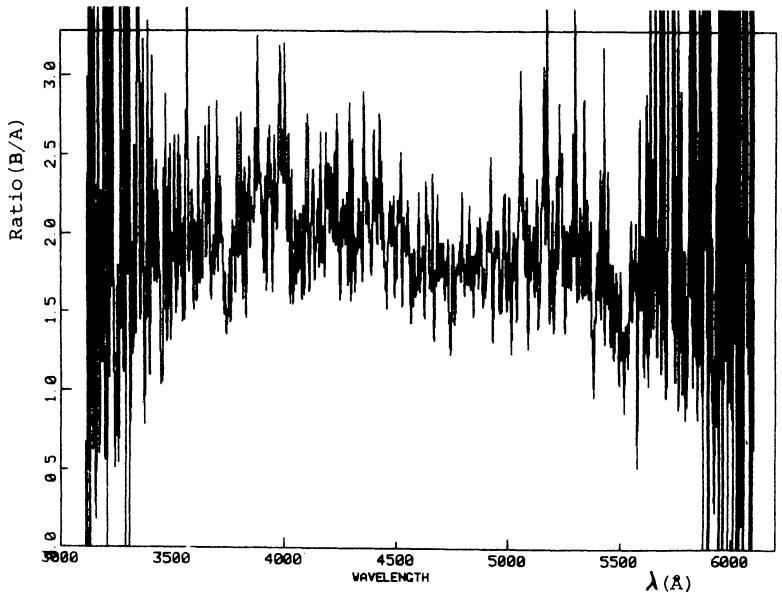

Figure 5 :

Scan of Q0107-025 B divided by that of Q0107-025 A.

3. Deep CCD frames of the field around Q0107-025 A and B

With the ESO CCD camera at the Danish 1.5 m telescope and during good weather conditions, several deep frames of the twin quasars were obtained in december, 1981 and january, 1982, using the g, r, i and z Gunn filters. Standard aperture magnitudes (with an aperture diameter equal to 5 arcsec.) were measured to be : g = 17.91 ± 0.02 (exp: 45 min.), r = 18.10 ± 0.02 (exp: 120 min.), i = 18.21 ± 0.02 (exp:105 min.), z = 18.01 ± 0.03 mag. (exp: 45 min.) for Q0107-025 A, and g = 17.31 ± 0.02, r = 17.42 ± 0.02, i = 17.51 ± 0.02 and z = 17.41 ± 0.03 mag. for Q0107-025 B. The zero points of these magnitudes were checked by observing the nearby standard star BD+21 607 and the mean errors affecting the magnitude determination are mostly based on photon statistics. The zero points should be accurate to within 0.02 mag., the accuracy of the QSO magnitudes being mostly set by the reliability of the former. By and large, we may state that the magnitude difference between Q0107-025 A and B is roughly equal ($\Delta m \sim 0.65$) in the four Gunn filters. Figure 6 reproduces a composite frame resulting from the addition of each single ones (exp: 315 min., Q0107-025 A and B being labelled 11 and 26, respectively). Although we intend to report elsewhere on a detailed analysis (type of object, magnitude, etc.) of all objects present on this frame, let us just mention that objects labelled 9, 10, 17, 19 (very red), 20, 21, 23, 27 and 28 in Fig. 6 are definitely classified as galaxies. An additional set of CCD frames, even deeper still, were obtained with the same equipment in november, 1982; they are presently being reduced.

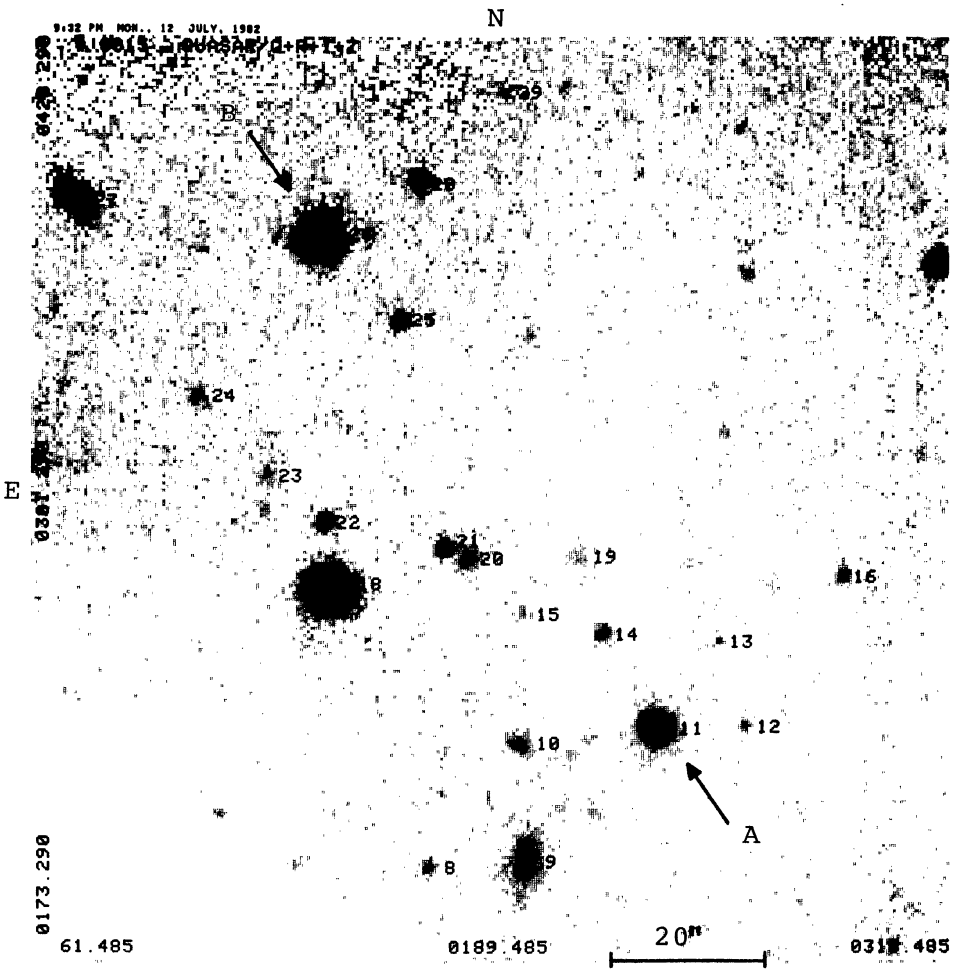

Figure 6 : Composite CCD frame (exp: 315 min.) of the field around Q0107-025 A and B (see text).

4. Twin quasars or gravitational lens ?

Considering the redshift difference $\Delta z \sim 0.004$ observed between the two quasars as well as their large angular separation of 77 arcsec., it is far more conservative to suppose that Q0107-025 A and B are located within a cluster or group of quasars - if a binary quasar is considered, the similarities observed in their spectra would naturally suggest that they have a same origin and underwent a similar evolution; one is then confronted with the problem of quasar genetics !-. However, the striking similarities between the observed spectra (Section 2 and additional unpublished results) lead to envisage the possible alternative : could Q0107-025 A and B be the result of a gravitational lens ? For illustration and simplicity, let us consider a spherical lens acting as a point mass. The observed angular separation between the two quasars would then require a mass $M_L \sim 10^{**}(14.9 \pm 0.9)\ M_\odot$ for the gravitational lens (a cluster of galaxies ?), depending on its actual distance $z_L \in [0.1, 0.9]$. It could be that some of the galaxies detected in the vicinity of Q0107-025 A and B on the deep CCD frames are the brightest members of such a hypothetical cluster. Within this framework, it is easy to calculate the difference in light travel time between the two observed images of Q0107-025. We derive the following value $\Delta t \sim 10^{**}(3 \pm 1)$ years for $z_L \in [0.1, 0.9]$. Following Paczyński and Gorski (1981, Ap. J. (Letters), 248, L101), it is then realistic to assume that the apparent redshift difference observed between Q0107-025 A and B is caused by time variations in the spectrum of the real quasar.

In order to elucidate which of the two distinct models applies to the case of Q0107-025 A and B, we intend to complete very soon the reduction of further spectroscopic observations as well as deep CCD frames in order to place more stringent constraints. High resolution spectroscopy of Q0107-025 A and B is also foreseen in the near future in order to possibly detect - and study - the absorption line spectrum of this very interesting pair of quasars.

Acknowledgements

It is with both much respect and admiration that we should like to dedicate the present work to the memory of Peter Young who still contributes very much to our understanding in the field of quasars and gravitational lenses.

Part of this research has been supported by NATO grant 111/81.