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RESEARCH NOTE: CCD PHOTOMETRY OF BLAZARS 3C 345, 3C 446, AND 4C 56.27[1]

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RESUMEN

Presentamos un estudio fotométrico de los cuasares 3C 345, 3C 446 y 4C 56.27, mismos que han mostrado microvariabilidad con anterioridad y han sido considerados por otros autores como candidatos a ser afectados por microlentes gravitatorias. Insertamos nuestros datos de dos de los cuasares en sus curvas de luz históricas para mostrar sus estados de actividad en una época reciente.

ABSTRACT

A photometric study is presented for the quasars 3C 345, 3C 446, and 4C 56.27, which had previously shown microvariability and which had been proposed as microlensed systems by other authors. Our data for two quasars are inserted into their historical light curves, showing a relatively recent stage of activity.

Key words: **BL LACERTAE OBJECTS–INDIVIDUAL (3C 345, 3C 446, 4C 56.27) — GALAXIES–ACTIVE — GALAXIES–PHOTOMETRY**

1. INTRODUCTION

Variability gives us important information about the physical processes occurring in the central regions of Active Galactic Nuclei; these variations were found shortly after the time when quasars were discovered. In the optical wavelengths, variability has been established since the early sixties (Matthews & Sandage 1963; Sharov & Efremov 1964).

Blazars involve two types of strongly violent extragalactic objects: BL Lacertae objects (BL Lac) and Optically Violent Variable Objects (OVV). The word “blazar” was introduced by Spiegel (see Burbidge & Hewitt 1991), and was obtained combining the “BL Lac” and “Quasar” terms. Both of them have as common features their violent optical variability, a compact radio source with a flat spectrum and a high polarization level. The energy that we receive from them, comes almost exclusively from their plasma-jets (aligned with our line of sight).

Many models have been explored to explain the violent variability of blazars. Since most of the emission originates in a relativistic jet (e.g., Bregman 1992), variability is related to instabilities propagating along the jet, and/or direction changes (e.g., Marscher 1990, 1992). Even though many of these models work quite well in particular cases, they still cannot explain the complete light curves, which are extremely complex. Periodicity has been confirmed in only one case: OJ 287. This was made possible by means of a very well organized international monitoring campaign (Sillanpää et al. 1996). The problem for most blazars, however, is the lack of well sampled observations.

For short time-scales, modeling the activity of blazars is even more difficult. It is possible that some of the microvariability scenarios are caused by an extrinsic phenomenon; the most popular scheme attempting to explain these events is the micrograv-itational lens (Kayser, Refsdal, & Stabell, 1986; Griest 1991; Schneider, Ehlers, & Falco 1992; Paczyński 1996). In this work, we chose the quasars 3C 345, 3C 446, and 4C 56.27, previously proposed by Schramm et al. (1993) and Schramm et al. (1994) as candidates for gravitational microlensing effects.

3C 345 has been observed since 1965 (Kinman et al. 1968), and since then it has shown variability

[1] Based on observations collected at the Observatorio Astronómico Nacional, San Pedro Mártir, B. C., México.

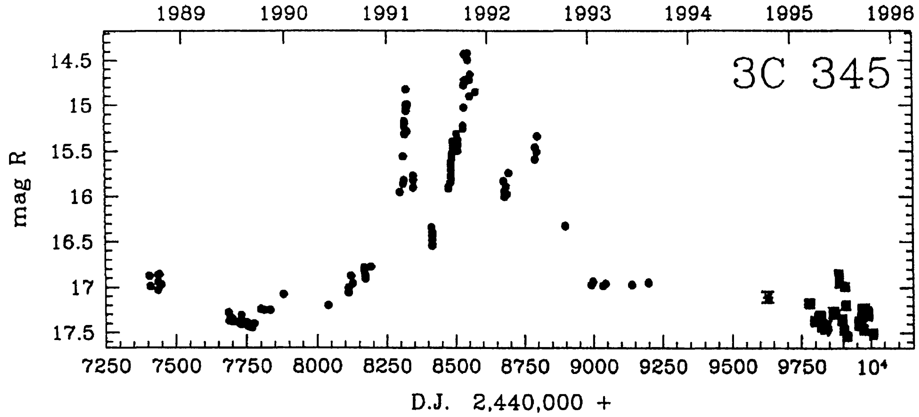

Fig. 1. R-filter light curve for 3C 345 from 1988 to 1995. Filled circles were taken from Schramm et al. (1994); filled squares were from Villata et al. (1997); our datum is shown by an asterisk with error bars.

at optical frequencies (Goldsmith & Kinman 1965). Today it is one of the best sampled violently variable quasars. At the beginning of the 90's, Stickel (1992) found an object that might be a foreground galaxy interposed over the line of sight. An interesting scenario for this object was proposed by Schramm et al. (1993) and Wagner (1993), who presented a geometrical model to explain a triple outburst produced at the beginning of the 90's (see Figure 1). They concluded that the flares occurred through variable relativistic beaming of a knot moving on a helical orbit in the jet.

For 3C 446, photometric data are available since 1964 (Sandage 1965). Since then, violent optical variations have also been observed (Sandage, Westphal, & Strittmatter 1966; Webb et al. 1988). Recently, Schramm et al. (1994) found 1.5 mag variations in only a few days.

There are very few data for 4C 56.27. Cohen et al. (1977) identified the optical counterpart of the radio source. Burbidge & Hewitt (1991) compiled the known data for this quasar. There are no photometric analyses other than Schramm's R-band, differential work (Schramm et al. 1994). This object was chosen because of the possibility of violent variability, as it is a BL Lac object.

2. OBSERVATIONS AND DATA REDUCTION

The objects were observed on 1994 September 26^{th} and 28^{th}, using a large format blue-coated Thompson 1024 × 1024 CCD detector, with a Cousins' R filter, installed at the 2.1-m telescope of the Observatorio Astronómico Nacional at San Pedro Mártir, Baja California, México. The standard stars were taken from Smith et al. (1985), and the extinction coefficients were calculated using the extinction curves reported by Schuster (1982) for San Pedro Mártir. The data reduction was carried out with CCDRED and APPHOT packages within IRAF, using a circular aperture of 2″.34 for the blazars (obtained maximizing the signal-to-noise ratio, and applying a cutoff at sky + $3\sigma_{sky}$ value). The plate scale was 0″.26 per pixel.

TABLE 1

OBSERVED AVERAGE NIGHTLY MAGNITUDES FOR QUASARS

Object	Julian Date	R (mag)[a]	t_{exp} (min)[b]
3C 345	2449623.6	17.10 ± 0.06	67
3C 446	2449621.8	17.44 ± 0.08	70
4C 56.27	2449621.7	16.90 ± 0.02	53

[a] The magnitudes and errors were computed averaging all frames of each object. The aperture radius was 2″.34.
[b] Total exposure time for each object.

The data were obtained as follows: on September 26^{th}, 2 frames were taken (1800 and 2400 s) for 3C 446, 4 frames (180, 600, and 2 of 1200 s) for 4C 56.27; for 3C 345, 3 frames were observed (of 420, 1200, and 2400 s) on the night of September 28^{th}. Finally, the average magnitude was computed for each object. The corresponding errors in the magnitudes were calculated from the repeatibility of the various measurements, including an estimate of the atmospheric extinction error. Table 1 shows the object's name in the first column, and the Julian Date in column 2; columns 3 and 4 give the average nightly R magnitude with its errors and total exposure time. The epochs of the observations are given in Julian Dates in order to include them in the historical light curves.

In what follows, the resulting light curves are shown for two of the objects in order to analyze their photometric behavior.

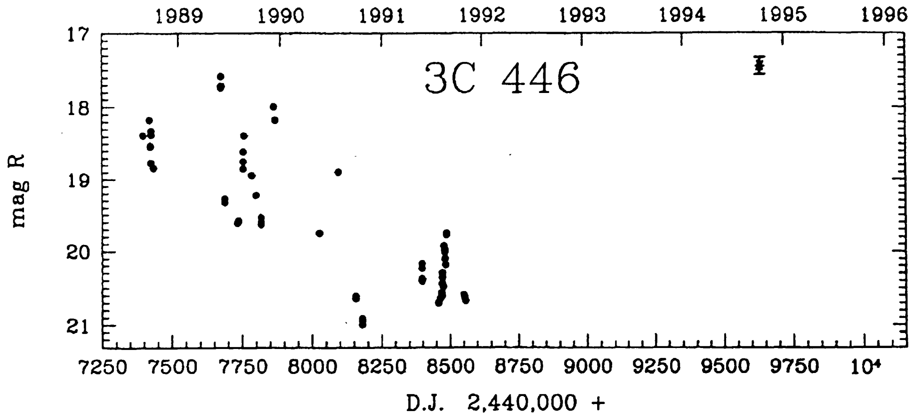

Fig. 2. R-filter light curve for 3C 446 from 1988 to 1994. Filled circles were taken from Schramm et al. (1994) and again our datum is shown by an asterisk with error bars.

3. RESULTS AND DISCUSSION

The averaged magnitudes, given in Table 1, were added to the historical light curves (Figures 1 and 2). We did not plot a light curve for 4C 56.27, because of the practical absence of photometric data in the literature. Our data are the first ones potentially useful for a future long-term variability study.

The light curve of 3C 345 (Fig. 1) was taken from Schramm et al. (1993, filled circles) and from Villata et al. (1997, filled squares). Our data (shown by an asterisk with error bars) link the measurements of other authors, and set a limit to the time it took for the object to get back to its quiescent state. Our data clearly show that by 1994 the object was back to its quiescent state, making the curve and the triple feature distinctly symmetric. This kind of feature has been attributed to emission of a shock moving in a helical jet by Schramm et al. (1993, 1994). The model, however, has to be refined in order to explain the details of the observed light curve.

For 3C 446, our data were appended to the light curve from Schramm et al. (1994, filled circles in Fig. 2). To the best of our knowledge, there are no photometric data after 1994. Measuring the magnitude variation between the faintest data from Schramm's paper and ours, we find a change of $\Delta R \simeq 3.6$ mag in five years. This indicates a rise of the object's luminosity to its previously brightest stage. Similar changes had been a common feature in the blue (B) light curve for 3C 446 as shown by Webb et al. (1988). It is not possible to answer with our limited observations whether this luminosity increase was due to a long-term variation, or it was part of an outburst. The answer to this type of questions can only be obtained by means of long-term monitoring programs. This object is a very interesting target for future multifrequency monitoring campaigns.

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