

## A Polarization Flare in 3C 273: A Clue to Jet Physics

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**Abstract.** We present *UBVRIJHK* polarization and flux density observations of the quasar 3C 273 obtained during a time of outburst over two weeks in 1988 February. We have modelled these data with two power law components, each with wavelength-independent position angle. These components are roughly perpendicular. The steeper-spectrum component has higher infrared polarized flux density, with the electric vector approximately transverse to the projected direction of the VLBI jet. The K-band polarized flux density and position angle, and possibly the spectral index of the two components, are correlated with a time lag of less than a day. We explain our results in terms of a shocked jet model with two nearly co-spatial components: a shock component with magnetic field approximately perpendicular to the jet and the other with magnetic field approximately parallel to the jet.

### 1. The Data

Our data consist of polarization position angle (E-field), percentage polarization, and total flux at *UBVRIJHK* for 3C 273 for each night of UT 10, 12–18 February 1988. The data for a representative night (12 Feb.) are shown in Figure 1, where the solid lines represent the best-fitting model for that night (see §2). The data were taken at UKIRT with the Mark II Hatfield Polarimeter (Hough, Peacock, & Bailey 1991), which makes simultaneous optical and near-infrared observations, important for this variable blazar. The data have been corrected for interstellar polarization and Galactic extinction. A brief discussion of these data was presented by Wills (1991).

At the time of our observations 3C 273 was in an outburst state (Courvoisier et al. 1988). This outburst has since been associated with the ejection of VLBI component C9 ( $t_0 = 1988.1 \pm 0.1$ , Bååth et al. 1991). At this time the polarization was higher than usual.

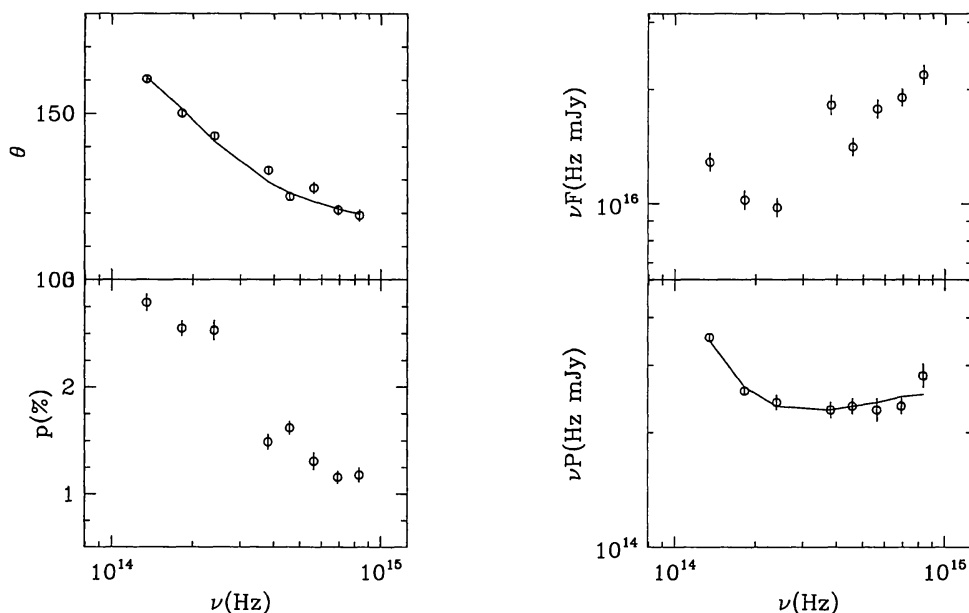


Figure 1. Frequency-dependence of polarization position angle and percentage, total and polarized flux (in mJy), corrected for Galactic extinction and interstellar polarization, for 12 February, 1988. Solid line represents the best-fitting model. The high value of the total flux in I-band is due to the presence of the  $H\alpha$  line in this band.

In our data both the percentage polarization and the position angle are very frequency-dependent, and this dependence changes from night to night. The frequency dependence of  $\theta$ , particularly a  $90^\circ$  flip on 14 Feb., is suggestive of the presence of two perpendicular polarized components of similar amplitude but different spectral shape.

## 2. Modelling

We have modelled our data with two power laws in polarized flux density that vary from night to night in amplitude, spectral index, and position angle. The addition of two such components for 12 Feb. is illustrated in Figure 2. In all cases we find that the two components are approximately perpendicular, with the E-vector of the steeper component transverse to the projected jet direction. The model reproduces the data well. Slight changes in the model parameters (for example,  $< 3^\circ$  in position angle,  $< 0.05$  in spectral index, and  $< 0.05$  mJy in amplitude) produce noticeably worse fits to the data. The two-component models are thus well-constrained by the data. We find that the components are correlated in amplitude and position angle, and probably spectral index (significance levels of  $> 99.75\%$ ,  $> 99\%$ , and  $> 93\%$  respectively) with a time lag of much less than one day. The changes of the amplitudes and position angles of the components with time are illustrated in Figure 3.

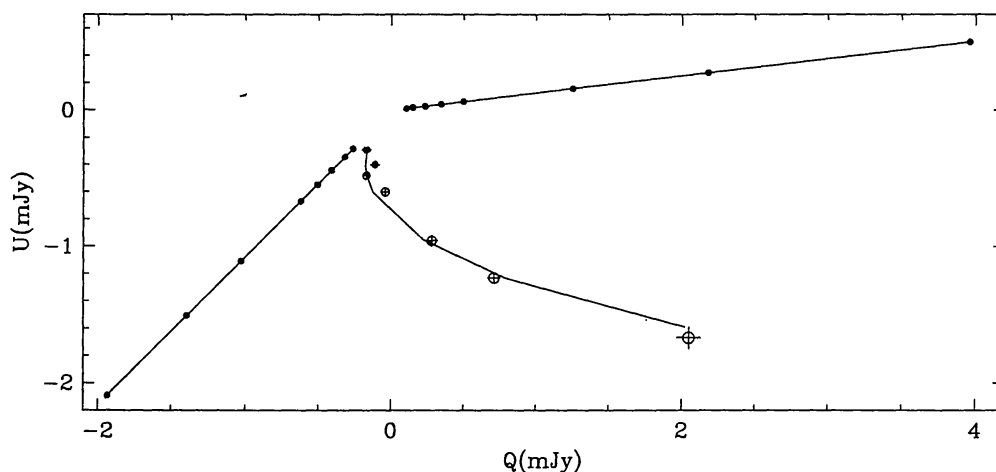


Figure 2. Polarized flux, best model, and model components for 12 February, 1988 in Stokes parameter representation. Circle size indicates wavelength, with larger circles for longer wavelength. Filled dots represent  $Q$  and  $U$  of the model components at the wavelengths of the passbands. The components add vectorially to give the total model.

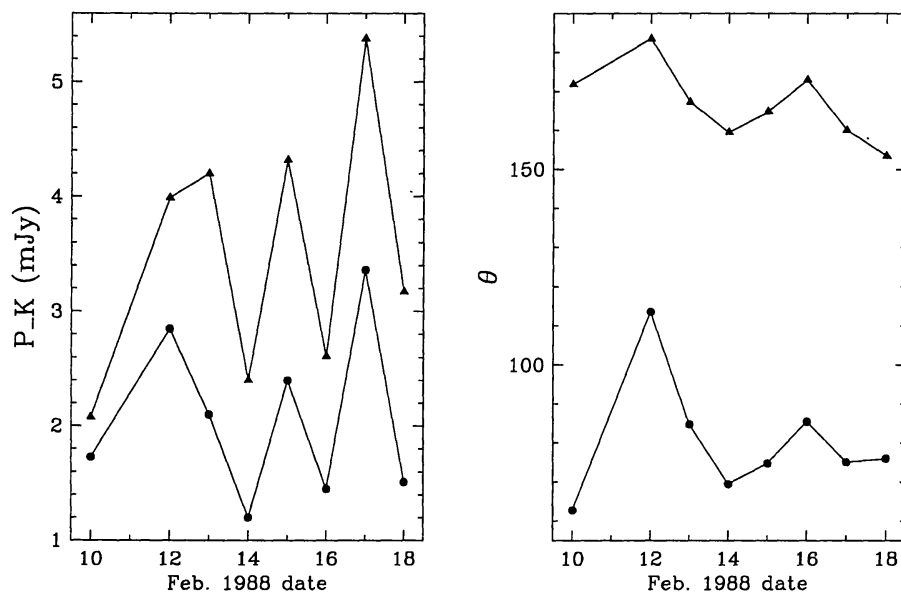


Figure 3. Changes of model  $K$ -band amplitude and position angle for the two model components as a function of time. Circles represent component 1, which is approximately parallel to the VLBI jet, and triangles represent component 2, perpendicular to the jet. The parameters for the two components generally rise and fall together. Results are similar for the model spectral indices. For clarity data for each component are connected by straight lines.

### 3. Discussion

We explain the polarization of 3C 273 in outburst with two synchrotron components. Since these components are nearly perpendicular they tend to cancel each other out, resulting in low polarized flux. This blazar-like polarization is further diluted by a strong, unpolarized non-blazar continuum, resulting in the low observed percentage polarization for this object.

The outburst emission of blazars is often explained in terms of a shocked jet model like that of Marscher & Gear (1985). Such models normally involve a quiescent component and a shock component. We instead require two components associated with the shock. These components must be nearly co-spatial to account for the very short time lag between their polarizations. The simplest model would involve an underlying magnetic field that is parallel to the jet, but which is compressed so as to be perpendicular in the region of the shock. One of our components, which has polarization parallel to the jet and a flatter spectrum, would originate from the region of the perpendicular B-field, as expected from the Marscher & Gear model. The other component, with perpendicular polarization, would be due to high energy electrons that have leaked from the shocked region and are accelerated where the B-field is parallel to the jet. We see these two components superimposed.

### References

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