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Circular Polarization of Intraday Variable Sources

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Abstract

We present circular polarization observations of the intraday variable sources PKS 0405−385 and PKS 1519−273. We find strong ($> 1\%$) and variable circular polarization for PKS 1519−273, well correlated with fluctuations in the total flux density at 4.8 and 8.6 GHz. The circular polarization of PKS 0405−385 is weaker and less correlated with the total intensity, but shows fast variability on a timescale similar to the total flux density changes. We find no simple explanation for the origin of the circular polarization.

1 Introduction

Circular polarization (CP) in extragalactic sources is weak and has been difficult to measure reliably. The Australia Telescope Compact Array (ATCA) was designed with the ability to measure low levels of circular polarization and is now providing excellent results. In this paper we present ATCA polarimetric data for two compact intraday variable (IDV) sources PKS 0405−385 and PKS 1519−273.

PKS 0405−385 is a $m_V = 18.5$, $z = 1.285$ quasar in which we discovered extreme IDV in the total intensity in June 1996 (Kedziora-Chudczer et al. 1997). This IDV episode lasted only two months and IDV did not recur until two years later, from November 1998 to April 1999. PKS 1519−273 is a $m_V = 18.5$, $z > 0.2$ BL Lac in which total and polarized flux density IDV was discovered during our ATCA IDV Survey (Kedziora-Chudczer et al. 1998).

2 Observations

Total and polarized flux density measurements of **PKS 0405−385** from 1999 January 15 are shown in Figure 1. The start of the November 1998 IDV episode was characterized by rapid, weak fluctuations, but by January the variability timescale had doubled and the amplitude increased. The modulation indices of the total flux density at 8.4 and 4.8 GHz were 2.3% and 3.1%, respectively in November 1998, and 11.1% and 9.8% in January 1999. The mean CP over this second period was $\langle V\rangle/\langle I\rangle \approx 0.2\%$, however the CP was variable with no significant correlation with the total flux density.

The amplitude of the variations in **PKS 1519−273** is comparable to that in PKS 0405−385 but its timescale is slower (cf. Figs. 1 & 2). Figure 2 illustrates the high CP and its strong correlation with the fluctuations in total intensity, indicating an identical origin for their variability (Macquart et al. 2000). From this we can derive the degree of CP of the variable component: $-2.6\pm0.5\%$, $-3.8\pm0.4\%$ and $-2.4\pm1.3\%$ at 8.6, 4.8 and 2.5 GHz respectively.

3 Discussion

We argue that the IDV of PKS 0405−385 is caused by interstellar scintillation (ISS) of a microarcsecond component (Kedziora-Chudczer et al. 1997). Our measurement of the time-delay in the arrival of the variability pattern of this source between the VLA and the ATCA is a persuasive argument (Jauncey et al., this Symposium) that IDV in general is caused by ISS. The characteristics of the variability in PKS 1519−273 also favour ISS (Macquart et al. 2000). Scintillation-based size estimates imply $T_B \approx 2\times10^{14}$ K for PKS 1519−273 and $T_B \approx 5\times10^{14}$ K for PKS 0405−385.

The characteristics and degree of CP detected in the variable component of PKS 1519−273 are difficult to reconcile with theory. The high fractional CP observed in the variable component decreases sharply between 4.8 and 1.4 GHz, in disagreement with $\nu^{-1/2}$ dependence expected from the synchrotron theory.

CP may arise due to conversion of linear polarization to CP (circular repolarization) in a relativistic pair plasma, analogous to the effect of Faraday rotation. Such conversion is characterized by a strong frequency dependence on the sign of the CP. However, we detect no changes in the

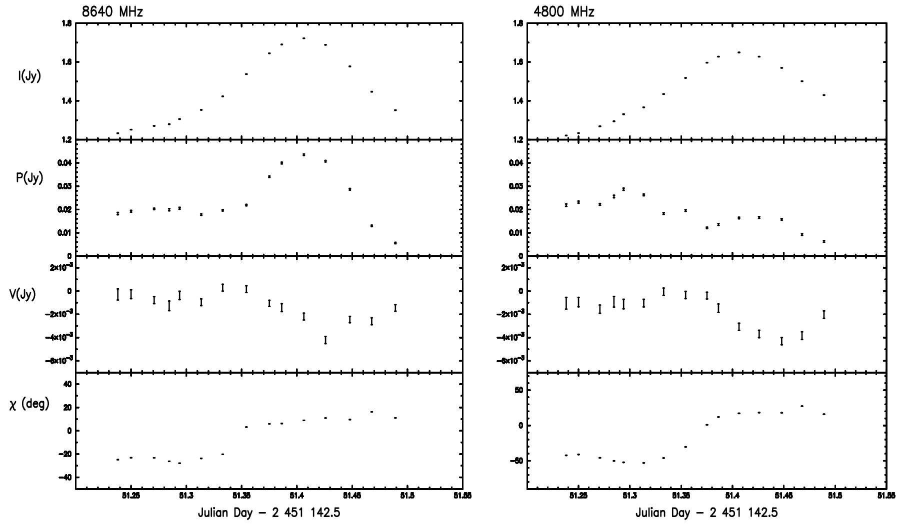

Figure 1: Variability of PKS 0405−385 in the total intensity (I), CP (V), and magnitude and position angle of the linear polarization (P and χ) at 4.80 and 8.64 GHz over 12 hours on 15 Jan 99. Each point represents a 20 min average, and is plotted with $1\,\sigma$ error bars.

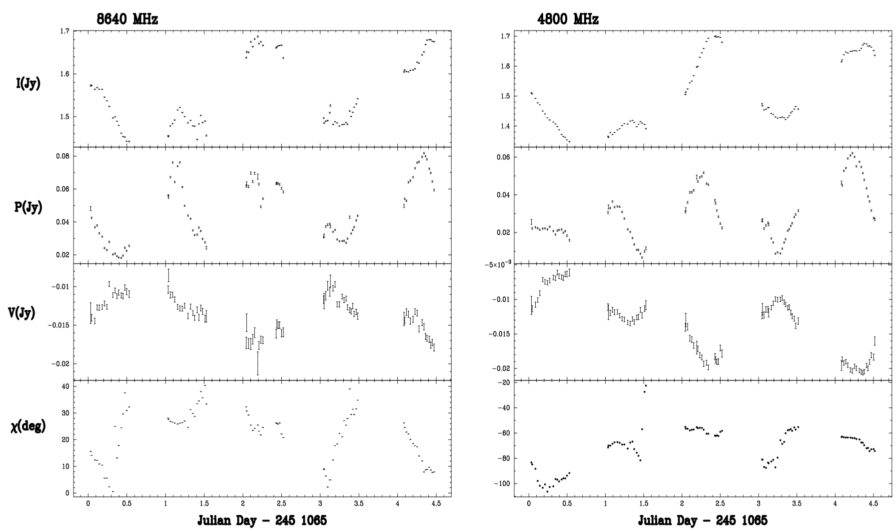

Figure 2: Variability of PKS 1519−273 at 4.80 and 8.64 GHz over 5 days. Each point represents a 10 min average, and is plotted with $1\,\sigma$ error bars.

sign of the CP between 8.6 and 1.4 GHz.

Inhomogeneity and optical depth effects in a pair plasma (Jones & O'Dell 1977) may account for CP *provided that* the self-absorption frequency is between ≈ 3.4 and 6.7 GHz. This is difficult to confirm since the intrinsic spectrum of the variable component is unknown.

4 Conclusion

The observed variability of PKS 0405−385 and PKS 1519−273 are both well explained by scintillation theory. The associated variability in the CP is also likely due to ISS but the two sources differ substantially in their degree of CP and its correlation with the total intensity. The exceptionally high CP in PKS 1519−273 is difficult to account for with simple existing models (Macquart et al. 2000).

If an explanation of the origin of the high brightness temperatures of these sources demands we abandon the hypothesis that their emission is due to synchrotron radiation, it is tempting to speculate on its connection with the CP.

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