Spectral and Correlation Analysis for Multiple Wavelengths of PMN J 2345-1555

Yunguo Jiang (姜云国)

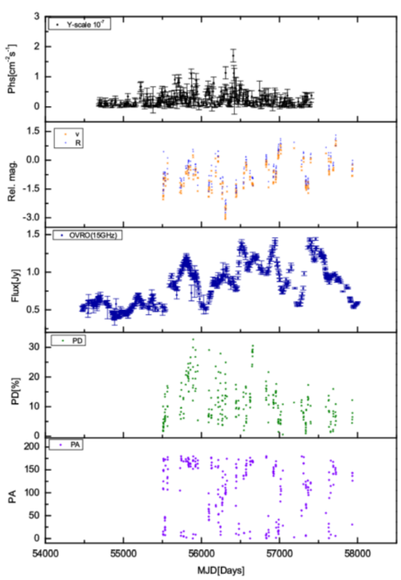
School of space science and physics, Shandong University at Weihai

Abstract

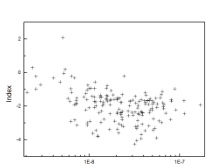
We report the multiple-wavelength light curves of the PMN J2345-1555 and make a correlation analysis between them. The localized discrete correlation function (LCCF) is used to analyze the correlations between various light curves, and also the Monte Carlo simulations are performed to obtain the significance range for the correlation. The gamma-ray spectral indices are anti-correlated with the flux, while the color index is independent of the magnitudes. The optical V band and the V-R color index lags behind the radio light curves about 221 and 164 days, respectively (beyond 3 sigma) . We also found a correlation between the radio and the optical polarization. This indicates that the magnetic fields play an important role in the jet dynamics.

Light curves

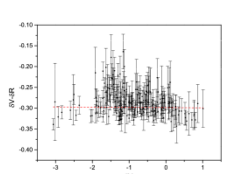
The radio, optical and gamma data are taken from the public OVRO, Steward and Fermi websites, respectively. The gamma data were reduced using the binned likelihood method of Fermi Science tools, and 7-year light curves were obtained . The optical data include the V and R and, also the polarization degree and polarization angle.



Spectral index VS flux



Gamma ray spectral indices are fitted by the single power law, and the index versus the gamma-ray flux is plotted. A anti-correlation between the index and the flux is possible .



The V-R color index versus the V band relative mag. is plotted. The red dash line has a slope 0.0005. The variation of color index is independent of the optical flux.

From the two plots, it is also possible that the spectral index for gamma-ray and the color index of optical have a broken power law relation with the corresponding flux. This indicates a different emission processes when the flux is low and high.

Correlation analysis

We use the localized cross-correlation function (LCCF) to study the correlations between different Light curves (Welsh 1999). LCCF is efficient than the DCF in picking up the physical peaked lags (Max-Moerbeck 2014). In order to estimate the significance of the time lags, the Monte Carlo (MC) method is applied to indicate the significance of correlation coefficients.

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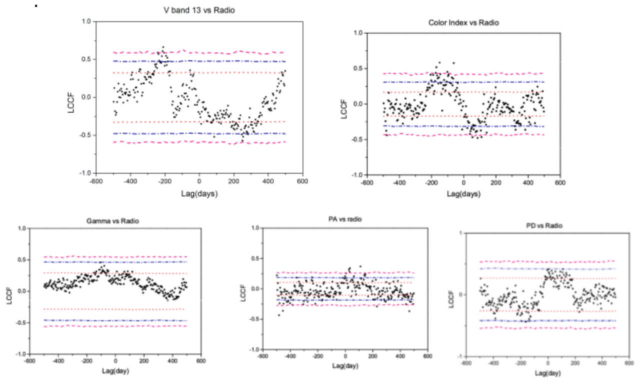
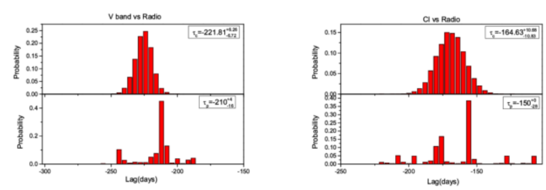


The time lags and its 1 sigma error range are simulated by the FR/RSS MC simulation (Peterson 1995).



	Color index	V-band	Gamma-ray	Polarization degree	Polarization angle
τ_c	$-164.63^{+10.68}_{-10.83}$	$-221.81^{+6.26}_{-6.72}$	$-103.51^{+9.57}_{-8.69}$	$33.08^{+6.80}_{-7.19}$	$26.43^{+10.92}_{-9.34}$
τ_p	-150^{+0}_{-28}	-210^{+4}_{-16}	-106^{+28}_{0}	18^{+68}_{-24}	30^{+4}_{-24}

Discussion and conclusion

a) Ghisellini et al. have studied PMN J2345, and found its bolometric luminosity varies more than one order of magnitude. This is explained by that the emission region varies from inside the broad line region to the outsides. The same can explain the complex behaviors of the spectral index versus the flux.

b) The optical leads to the radio, most possible reason is that the optical is produced via synchrotron, while the radio 15 GHz emission is due to the synchrotron absorption. The optical emission region is very compact, while the radio emission region is very large, i.e., about 20 pc. The optical emission may correspond to the core of the jet in radio images.

c)No correlation between the gamma-ray and the optical is found, this indicates the gamma-ray is produced by EC or by both EC and SSC. The lag time between gamma and radio also support the EC process.

d) Both PA and PD is correlated with the radio, and the positive lag time indicates that they lag behind the radio variation. The PA of synchrotron emission is determined by the projection of the magnetic field onto the observation sky. This indicates that the magnetic filed is cospatial with the radio emission region, spread in the 20 pc scale. The topology of the magnetic fields varies with the jet. This means the magnetic field plays an important role in jet dynamics. The correlation between PA and radio indicates the magnetic field configuration is the dominant ingredient to determine the PA.

Comments and criticism are welcomed!

jiangyg@sdu.edu.cn