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Multiwavelength analysis and modeling of OJ 287 during 2017–2020

OJ 287, a proposed binary black hole system, is an interesting object for multiwavelength study due to its periodic outbursts. We analysed the optical, X-ray, and γ-ray data of OJ 287 for the period of 2017–2020. Based on the observed variability in optical and X-rays, the entire period is divided in five segments as A, B, C, D, and E. To understand the temporal variability in this source we studied the intraday and fractional variability for all the various states. Furthermore, the multiwavelength spectral energy distribution modeling was performed to know more about the physical processes responsible for the simultaneous broadband emission and the fast variability. A single-zone synchrotron self-Compton emission model is considered to model the SED, and this helps us to explore the nature of this BL Lac with binary supermassive black holes.

Observations

We analyzed the multiwavelength data of OJ 287 for the period of 2017–2020 from Fermi, SWIFT, OVRO, & ground based optical telescopes.

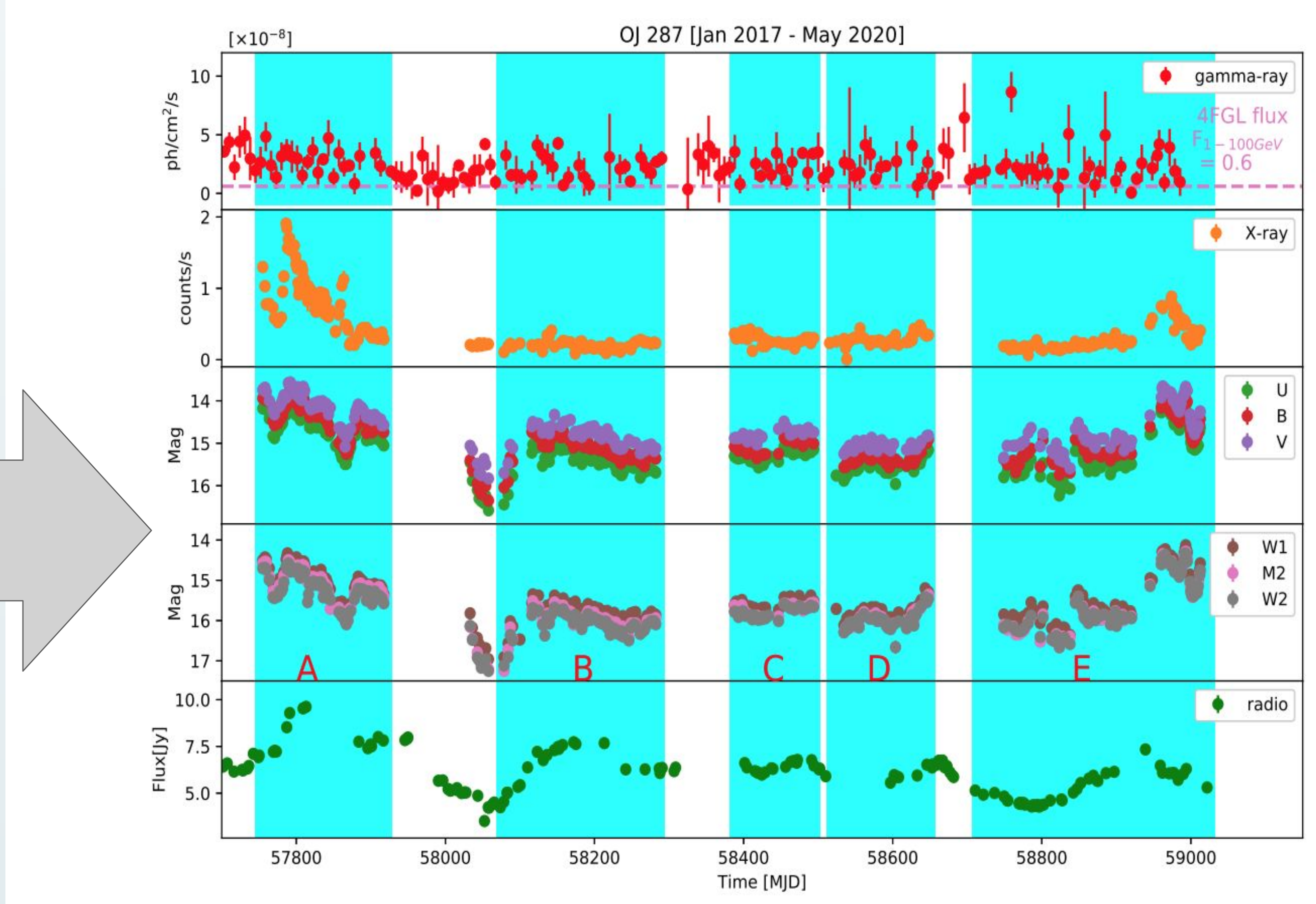

Fig. 1. Broadband light curve of OJ 287 from 2017–2020. *Panel 1* (top) shows the weekly binned γ-ray light curve for 0.1–300 GeV. *Panels 2, 3, and 4* are the *Swift*-XRT and UVOT light curves. *Panel 5* is the radio light curve from OVRO at 15 GHz. The entire light curve is divided in five different states based on the flux and magnitude seen in *Swift*-XRT and UVOT. The various states are denoted A, B, C, D, and E and their time duration is represented by the color patches.

Variability

Five states (A, B, C, D, and E) identified based on the flux and fractional variability seen in optical–UV and X-rays.
States A and E appear to be the brightest, as verified by the total jet power.
Variability timescale across the bands ranges from 12 h to 20 days: the fastest variability time ~ 1 day; U, B, and V have the shortest variability time of ~14 h, 30 h, and 18 h; UV bands are on the order of 1 day, 4 days; γ-ray data shows day scale variability and the maximum variation between high and low is 5 times.

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γ-ray data well fitted with the PL or LP model

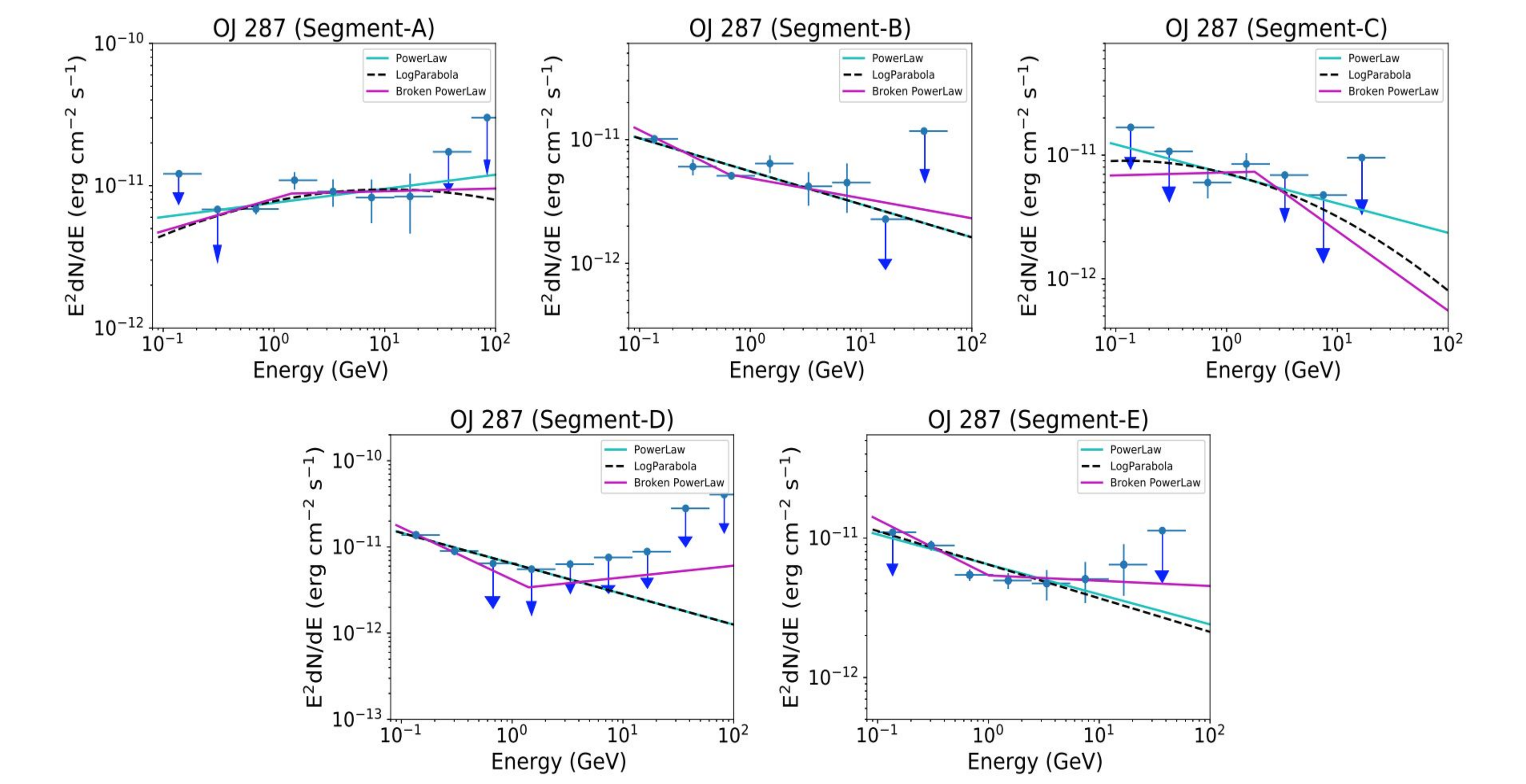
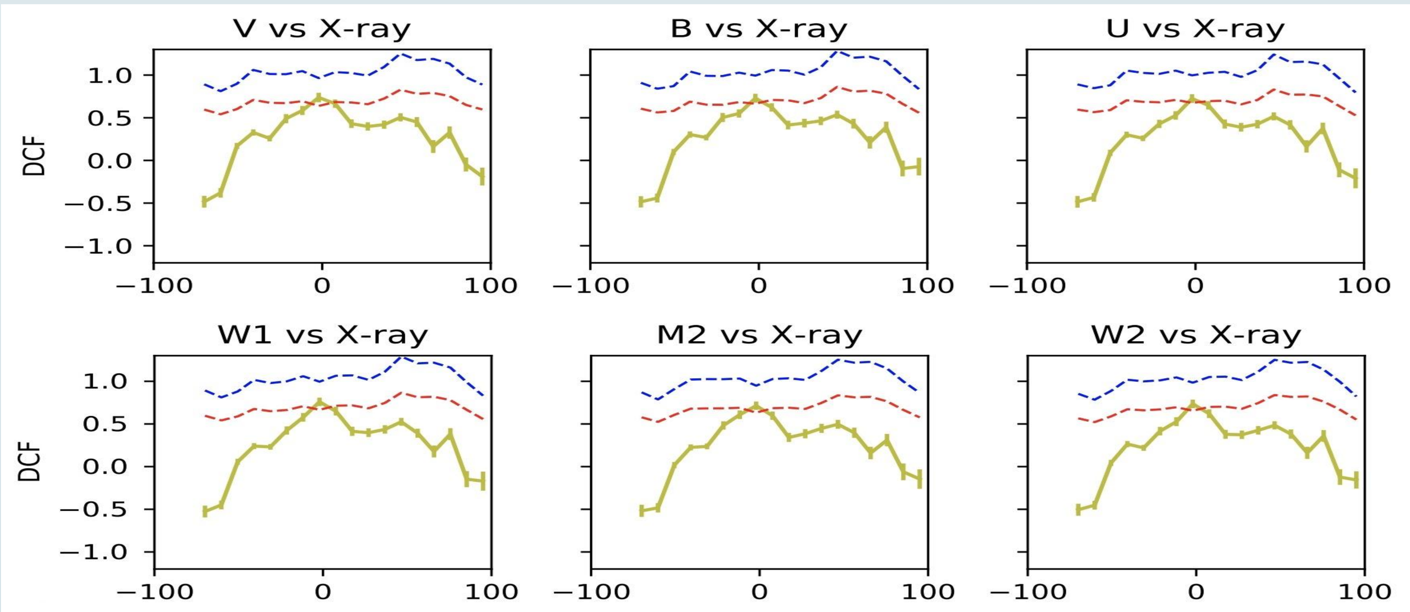


Fig. 3. Gamma-ray SED of all the segments identified during 2017–2020 in OJ 287 modeled with three different spectral models: PL, LP, and BPL (see Sect. 3.2 for more details). The down arrow represents the upper limit in that particular segment.

Correlations analysis between various frequencies shows that emission is highly correlated between the different bands, which suggests their co-spatial origin. Therefore, a single-zone emission model is applied to explain the multiwavelength emission



We used a publicly available time-dependent code GAMERA to model SED & modeling confirms the presence of high magnetic field in the jet, and that the jet emission is powered by relativistic electrons

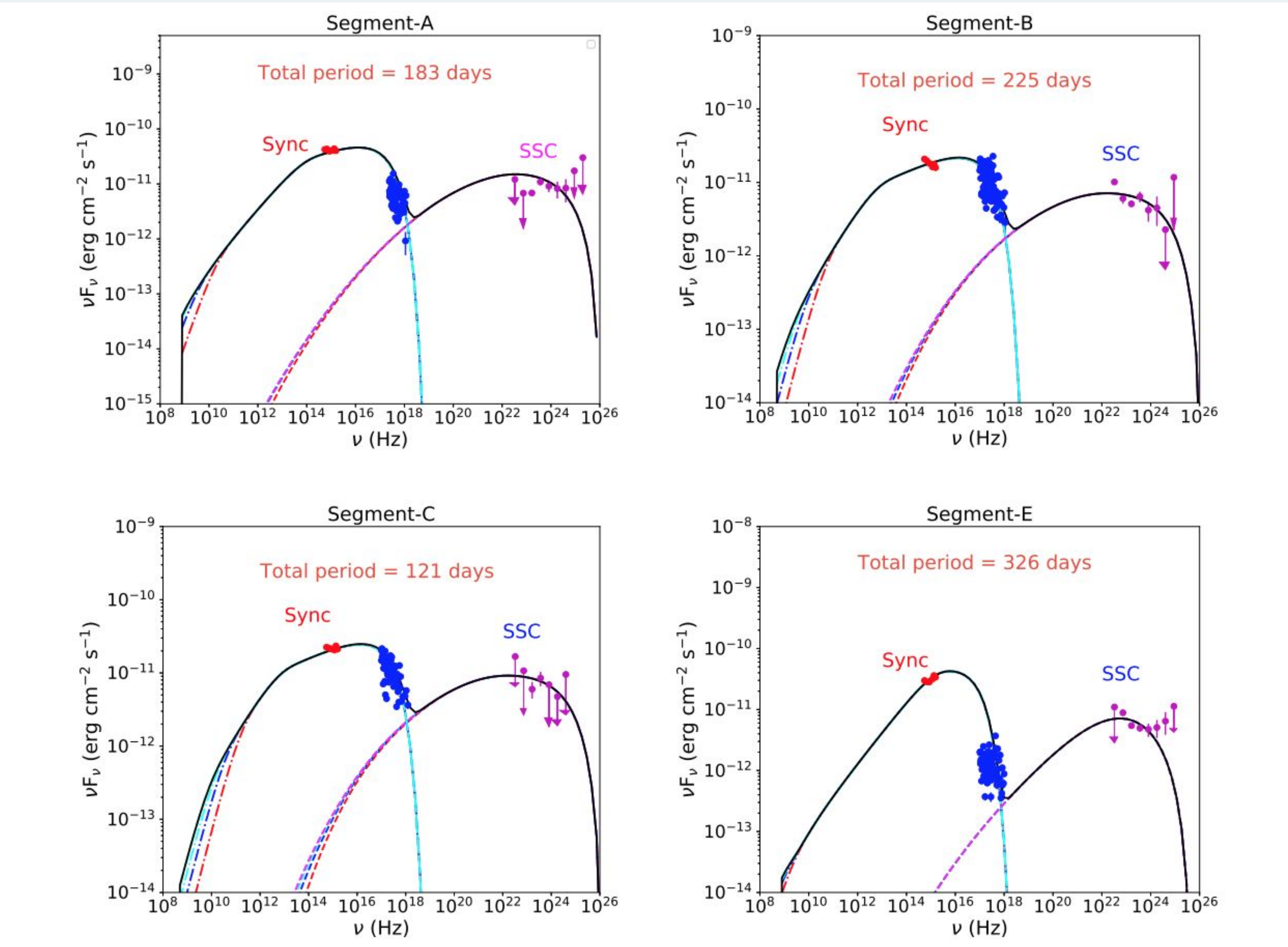


Fig. 5. Multiwavelength spectral energy distribution for all the various segments observed during the year 2017–2020. The dot-dahsed and dahsed line in different colors in the synchrotron and SSC peaks are the time evolution of the model. The down arrow represents the γ-ray upper limits. The optical–UV, X-ray, and γ-ray data points are shown in red, blue, and magenta.

1. **States A and E explained with disk impact model when thermal flares were observed.**
2. **During states B, C, and D there was no flare, hence a lower jet power is needed to model these low states.**
3. **Different behaviours at various frequencies and epochs makes this source very complex and thus many more observational and theoretical studies are required for OJ287**