Project: Disentangling the emission mechanisms of blazars

Level of the project: Master

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Project description

The extra-galactic gamma-ray sky is dominated by blazars, a subset of jet-producing, radio-loud Active Galactic Nuclei (AGN). This is because, for blazars, our line of sight lies very close to the direction of propagation of the relativistic jet, and the non-thermal emission produced in the jet is highly Doppler-boosted, greatly increasing the apparent luminosity of the observed emission. Blazars can exhibit strong flares and rapid variability over multiple wavelength regimes, the exact mechanisms of which are not yet fully understood. The spectral energy distributions of blazars show a double bump structure from the non-thermal emission, with the lower energy component extending from radio up to X-ray energies, and a higher energy component from X-ray up to gamma-ray energies. The lower energy component is produced via leptonic synchrotron radiation, while both leptonic and hadronic processes have been proposed for the higher energy component. However, it is difficult to differentiate between the two processes since it is possible to fit the observed SED using either model with different parameters (Böttcher et al. 2013).

One of the difficulties in modelling these sources is placing a constraint on the non-thermal electron population. This is because at optical wavelengths FSRQs, the observed emission is a superposition of the non-thermal emission originating from the jet and the thermal emission arising from the accretion disc, broad and narrow line regions, the dust torus, etc., which forms around the supermassive black hole. Measuring the brightness alone makes it very difficult to disentangle the different components. However, measuring the polarization can be used as a powerful diagnostic tool in blazar studies, as it provides a way to disentangle the unpolarized thermal and polarized non-thermal emission at optical wavelengths. This provides much better constraints on the jet's magnetic field at the emission region. To this end, over the last few years, we have been undertaking spectropolarimetry of known gamma-ray bright blazars, using SALT. Results from SALT have applied to two blazars, 4C +01.02 (Schutte et al. 2022) and PKS 1510-089 (H.E.S.S. Collaboration 2023), as well as investigated the long-term polarimetric behaviour of sources (Barnard et al. 2024). Beyond this, a dedicated systematic spectropolarimetry survey using SALT, of ~1/6 of all known TeV blazars (SPOTS: SpectroPolarimetry Of TeV Sources) is currently being taken.

The aim of the project is to disentangle the different emission mechanisms for a selection of the sources being observed as part of the current SALT survey. The objective is to model both the non-thermal emission and thermal emission for the sources, as well as the optical polarization to place better constraints on the underlying emission mechanisms.

References

Barnard, van Soelen, et al 2024 MNRAS 532 1991
Böttcher et al. 2013 ApJ, 768 54
H.E.S.S. Collaboration 2023 ApJ Letter 952 L38
Schutte et al. 2022 ApJ 925 139