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A new era for multi-wavelength studies of blazars with Rubin and the CTAO

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Both the Rubin Observatory and the first telescopes of the CTAO will be collecting data by 2026, marking a new era in optical and gamma-ray astronomy. Compared to predecessors like the ZTF, H.E.S.S., MAGIC, and VERITAS, their enhanced sensitivity will extend extragalactic observations to a redshift of at least ~ 2.5 . This advancement offers fresh insights into non-thermal astrophysical sources, particularly blazars - radio-loud Active Galactic Nuclei with jets aligned with our line of sight. The 3-night cadence monitoring with Rubin, in one of its six filters, will produce blazar light curves that, when combined with targeted in-depth observations from the CTAO, could help distinguish acceleration and radiative models, which are still under debate. Existing data from the ZTF and \textit{Fermi}-LAT, though less sensitive, offer preliminary insights into what Rubin and the CTAO may achieve. However, the real-time processing of the immense data stream coming from Rubin/LSST presents a major challenge.

Addressing this challenge is the work of brokers such as Fink, which we develop for multi-messenger astrophysics. Fink processes data in real-time before sending relevant information to other observatories like the CTAO. In this contribution, we present how we characterize the optical variability of blazars that emit in the gamma-ray range using the ZTF, with timescales spanning from the intra-night to multi-years. We identify properties in the resulting parameter space that could not only enable the identification of blazar-like sources, but also the characterization of the continuum of states. We describe our fast identification of transitions from one state to another, enabling the trigger of observations in the gamma-ray band when the blazar is flaring and of spectroscopic observations with the goal to measure the redshift of the source when the jet becomes faint and the host galaxy may become detectable. Finally, we review the communication channel we set from the ZTF to the CTAO via Fink for blazars and discuss its outlook in light of the Rubin Observatory. This method is also applicable to other astrophysical sources and helps lay the groundwork for a fruitful era for time-domain astronomy.

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