The light that comes from distant objects in the Universe is a messenger of their nature. The electromagnetic radiation spans from radio wavelengths, through the optical range, to the high-energy regime of X-ray and gamma-ray regime. The latter are the most interesting as they allow to look into the vicinity of the most powerful objects—active galactic nuclei, harboring supermassive black holes, blazars in particular. Blazars emit the bulk of their energy by a narrow, relativistic jet pointed towards the observers on Earth. What is fascinating about them, is that their luminosity if far from being constant—they exhibit transient flares that can increase their energy output by a factor of a thousand. They are also variable on a more steady levels that show some patterns, sometimes being nearly periodic. The changes in the light are ascribed to various phenomena, like binary supermassive black holes (our Galaxy has only one such black hole in its center, and it is a fairly quiet one), tidal disruptions of nearby stars, but also less clear and more complicated turbulent and microscopic changes in the accretion disks that power them, or the jets themselves. Many of the blazars' properties can be extracted from the light curves with sophistacated statistical techniques, constituting the toolbox of time series analysis. For example, the power spectral density—how much energy is released by light curve variability on frequencies corresponding to certain time scales—can be connected with physical parameters, like the mass of the central black hole or the inner radius of the surrounding accretion disk. Such a task is a subtle one, and needs to be undertaken with care, since a hastily performed statistical analysis can lead to very flawed conclusions about the nature of the source of interest.

In my research project I intend to use a variety of statistical methods—some well established; some rarely used in an astronomical setting; some developed by me—to characterize the high-energy blazar light curves in the most reliable way. Such aim requires extensive numerical simulations: we are dealing with signals that are believed to be inherently stochastic, which means that it is extremely hard to predict their future behavior, and that every blazar can look completely different to us.

Statistical techniques are widely applicable in a variety of fields, like physics and astronomy, but also in biology, ecology, genetics, physiology, metheorology, hydrology, geology, economy, and many more. For example, a rigorous treatment of EEG data can help cure epilepsy, and some of the methods I intend to use in this astronomical project have already been utilized in the biomedical research.

I hope to learn new things about the radiation of the most distant and powerful sources in the Universe, and that the results will find applications in other fields as well.