Report from

the Short Term Mission – STM

PERSON NAME:	***IOANNIS LIODAKIS***
HOME INSTITUTE	***STANFORD UNIVERSITY, PALO ALTO, USA, CA 94305***
HOST COLLABORATOR	***Dr. Nicholas MacDonald (nmacdona@mpifr-bonn.mpg.de)***
HOST INSTITUTE	***MAX-PLANCK INSTITUTE FUR RADIOASTRONOMIE***
DATE OF THE STM:	***21.09.2018-30.09.2018***

RadioNet has received funding from the EU's Horizon 2020 research and innovation programme under the grant agreement No 730562

Report:

1. Topic

The blazar research group at Stanford University does not currently have experience working with either the Turbulent Extreme Multi-Zone (TEMZ) model of blazar emission or the relativistic magnetohydrodynamic code PLUTO. MacDonald (MPIfR) is well versed in working with both of these codes and has a background in modeling the variability in polarized emission emanating from blazar jets.

Modelling the polarization emission from blazars has proven to be an important tool in understanding their structure and energetics, evidenced by the ever increasing ground based instruments with polarization capabilities as well as space missions (e.g., Imaging X-ray Polarimetry Explorer, IXPE) across multiple wavelengths.

The purpose of this STM was to set the framework for exploring the yet unknown nature of the X-ray polarization in blazars by modelling their radio and optical total intensity and polarization using different emission models (e.g. with TEMZ & PLUTO). This will allow us to investigate the behaviour of the high energy polarization and make predictions that could soon be compared to observations thus testing these different emission processes/models.

2. Proposed and Performed Work

During the STM Dr. MacDonald and I engaged in planning and distributing the work load of different aspects of the project between us in order to ensure its timely completion. During this time, I collected and analysed the necessary radio, optical (including polarization information, RoboPol program), and X-ray data to provide a benchmark for the simulations. MacDonald attempted to create simulated total intensity and polarization multiband light curves to be compared to observations.

In particular:

(i) Bayesian block analysis was used to infer both the characteristic time scales and amplitude variations present in single dish light curves of Mrk 421 and 501. Upon comparison with MacDonald's jet models this Bayesian analysis revealed shortcomings in the model's ability to reproduce these variations (for a given set of observationally motivated parameters). Further work is needed to bring the simulations closer to observations.

(ii) An attempt was made to create X-ray synchrotron polarization images/light curves via full Stokes polarized radiative transfer through the jet models. Unfortunately, current radiative transfer algorithms appear to break down at higher X-ray frequencies. MacDonald identified the root of the problem in the Gamma function approximations that are utilized to model the Bessel functions present in synchrotron theory. While these approximations are valid in the radio regime they are not valid for X-rays. Although we plan on taking steps towards a possible solution, at present, and with the current computational resources available, it is unclear whether there is a timely solution to this problem.

3. Cross-Disciplinarity

During the STM visit I was familiarized with both plasma (e.g., TEMZ) and magnetohydrodynamic (e.g., PLUTO) simulation codes. MacDonald introduced me to the basic principles, advantages and drawbacks of these two different codes as well as their simulating capabilities and computational overheads. This was particularly important in understanding the abilities as well as limitations of state of the art simulations to reproduce the observations. In return, I introduced Dr. MacDonald to Bayesian block analysis. This statistical analysis is a very useful way of comparing simulated model light curves directly to single dish observations. MacDonald plans to incorporate Bayesian block analysis into his future modelling efforts. The exchange of expertise between me and Dr. MacDonald during this STM undoubtedly forms a strong basis for future collaboration.

RadioNet has received funding from the EU's Horizon 2020 research and innovation programme under the grant agreement No 730562

4. Impact

Comparing the low and high energy polarization signatures of blazar jets is the only pathway to a deeper understanding of the nature of the magnetic fields within these objects. The proposed project will allow us, for the first time, to make predictions as to the nature of the high energy polarization of blazars. Moreover, given that IXPE will open the blazar X-ray polarization window, for the first time, the results from this project will widely impact future synergies between different groups, especially in the single dish and VLBI polarization domain, and shape the observing strategies of both low and high energy polarization monitoring programs in the near future.

5. Publications

We plan on publishing the results of this study in an international peer-reviewed journal as soon as we have finalized our analysis. Acknowledgement for the financial support provided by RadioNet will be included in this publication.

RadioNet has received funding from the EU's Horizon 2020 research and innovation programme under the grant agreement No 730562