PhD project in ASTROPHYSICS
(one page)

Title of the Project: *VLBI and time measurement: how radio astronomy and metrology can benefit from the use of Time and Frequency reference signals generated by national metrological institutes and provided to radio astronomy and geodesy observatories.*

Supervisor: Monia Negusini / Federico Perini

Scientific Case: Study of the impact of providing time and frequency references based on more precise and less noisy optical clocks than current local H-masers on single dish/VLBI very high frequency observations. Metrological applications of VLBI observations, with particular regard to the possibility of performing clock comparisons on intercontinental scales, towards the redefinition of the second.

Outline of the Project: Since 2015 the Medicina Radioastronomy Station is connected to the Istituto Nazionale di Ricerca Metrologica (INRIM), where the Italian primary clocks are located, whose frequency standards are spread through a coherent fiber link (Italian Quantum Backbone, IQB). Over the years, the infrastructure has been made increasingly more robust and reliable and has been simultaneously extended to reach the ASI Space Geodesy Station in Matera in 2018. The connection between national metrological institutes (NMIs) and radio astronomy and geodetic stations opens up the possibility of new observational techniques that can benefit both scientific communities. Furthermore, since 2018 the Medicina station has hosted a 2.4 m diameter antenna designed and built by the National Institute of Information and Communications Technology (NICT) to carry out broadband VLBI measurements with the aim of comparing optical clocks on an intercontinental basis. This technique is innovative to overcome the obstacles imposed by current clock comparison techniques using satellites in terms of cost and feasibility. Thanks to the combination of the coherent optical link between INRIM and Medicina and the VLBI broadband antenna located there, it was possible to compare the Ytterbium optical clock located at INRIM in Turin with the Strontium optical clock located in Japan through VLBI experiments (Pizzocaro et al 2021). Thanks to the extension of the IQB infrastructure to Matera Space Geodesy Center, it was possible to conduct a first geodetic common-clock experiment between the two VLBI antennas of Medicina and Matera (Clivati et al. 2020). This infrastructure and the skills acquired by IRA and INRIM in recent years are enabling for future developments, both in geodesy, with the upcoming installation of a new generation geodetic antenna (VGOS) in Matera, and in the radio astronomy field, with the next installation of the Korean triple-band receiver on the VLBI INAF antennas of Medicina, Noto and SRT.
For metrology, it is important to explore the feasibility of performing VLBI observations on an intercontinental scale using broadband VGOS and VLBI antennas for the comparison of optical clocks, if the observatories are connected to NMIs. For astronomy, the possibility of verifying the impact of providing time and frequency references based on more precise and less noisy optical clocks than current local H-masers on single dish/VLBI very high frequency observations. Potentially, all the INAF antennas could be reached by the same the same reference signal (common clock), thanks to an extension of the IQB to Noto and SRT, enabling new kind of observation strategy in collaboration with the Korea VLBI Network.

Contacts: monia.negusini@inaf.it, federico.perini@inaf.it

Clivati et al. (2020) "Common-clock very long baseline interferometry using a coherent optical fiber link," Optica 7, 1031-1037
Pizzocaro et al (2021) “Intercontinental comparison of optical atomic clocks via very long baseline interferometry”, Nat. Phys.. doi: 10.1038/s41567-020-01038-6.