Abstract

The current is meant to initiate a **Marie Curie Initial Training Networks (ITN)**. The scientific context is the study of **Active Galactic Nuclei** and their central engines (super massive black holes) via modern **interferometric** techniques and **multi-frequency methods**. The broadness of the scope allows a variety of contributions. The ultimate goal is to attract the financial support for ~16 graduate students distributed over 6-8 partners.

Introduction

Black holes fascinating as mathematical entities or inconceivable as dynamical environments, comprise the engines powering a vast variety of systems spanning from galactic stellar scale binary systems to the super massive black holes in **Active Galactic Nuclei** (AGN) sustaining some of the most complex astrophysical phenomena. Focusing on the **Galactic Centre** gives us a unique opportunity to study an almost 4-million solar masses black hole. Combining this insight with that from distant **AGNs** and in particular **blazars** which comprise the most exotic flavor of the former, is vital in understanding the physics of AGNs.

Fundamental questions as of the **structural evolution** and the **emission mechanisms** and how they influence the **observed variability** of those systems remain unclear. Tightly co-ordinated efforts of **high angular resolution** studies and **multi-frequency observations** are necessary for disclosing the details of the **emission processes** at play and the **physics** of those systems. In particular:

1. **high angular resolution imaging** can provide understanding for the **structural behavior** and help us understand what is its role in the **observed variability**, while

2. **multi-frequency analysis** can shed light upon the broad-band **emission mechanism** and consequently the physical processes at play**.**

Here we propose an ambitious framework that is meant to provide a solid scientific background of great scientific value for **training young researchers** (PhD students). The potential of the proposed platform extends beyond the field of astrophysics and allows training also in:

1. **Interferometric technique,** implying knowledge in **information management**, **imaging techniques**, **instrumentation**, which is a necessary investment in the future especially in the light of the incredible opportunities that the new instruments such as LOFAR, SKA and ALMA are bringing

2. **Instrumentation** with the involvement in building equipment for state-of-the-art telescopes.

It is of essential importance that the latter points are not meant to only prepare the next generation of astronomical staff but also to prepare scientists with the potential to occupy leading positions in related fields in industry. For instance, medical imaging, information management and technology, astronomical instrumentation industry, even scientific journalism and others.

The Framework

The scientific framework of the proposed plan can be condensed to three fields of study:

1. The **emission mechanism** and hence the physical processes at play in AGNs.

2. The reason for the often observed **intense variability**.

3. The possible correlation between **structural evolution** and observed **variability** and **emission mechanism**.

Naturally, its strength relies on the potential deposited in the **interferometery technique** and the **broad-band, multi-frequency** (ideally simultaneous) observations of the **galactic centre** and selected **AGNs**.

Interferometry: The Structural evolution

Interferometry in its principal form or its generalised one of aperture synthesis, has been the crucial leap in the quest of high angular resolution imaging. After being introduced in the radio astronomy, it is used at higher energies as well. Nowadays, there exist a wealth of interferometers covering: the long cm-regime (e.g. GMRT, WSRT), the mid and short cm-regime (e.g. VLA, ATCA, VLBA, EVN), the mm and sub-mm band (e.g. Plateau de Bure, SMA, CARMA at), the optical and infrared band (e.g. LBT, VLTI, KECK) and HESS, VERITAS covering the TeV energies. Even more impressive is the wealth of upcoming experiments such as LOFAR, MWA, LWA, KVN, SKA, ALMA. All this activity is readily indicative of the potential of the technique and the perspectives for creativity that are available in studying the structural evolution of AGNs. At the same time the foreseen instruments are introducing major scientific obstacles to be resolved related chiefly to imaging processing, information management and high computing demand. This opens up a vast field to be explored by PhD students with immediate applications to both in science and industry.

Multi-frequency studies: The Emission Mechanism

The mechanism responsible for the observed radiation is representative of the physical processes at the source. In the particular case of AGNs, the different scenarios that have been suggested for explaining the radiative processes imply also different spectrum variability characteristics. Hence, the spectrum variability studies are an excellent probe for the ongoing physical process. Given the broadness of the AGN spectrum (spanning from radio to TeV energies), the multi-wavelength study is necessary in order to understand the physics at those systems. Furthermore, the "panchromatic" approach, which ideally should be simultaneous at all bands, combined with interferometric studies can answer the long-standing question of how the structural evolution is related to the variability of the spectrum. Thanks to the ever-growing family of observational facilities both earthbound and in orbit, with ever-improving performance, nowadays, there exists the opportunity to conduct broad-band studies in a coherent and often simultaneous fashion.

Combining the knowledge

The **exchange**, **interplay** and eventually the **combination** of the knowledge gained at all the steps described earlier, is key to the understanding the AGN physics. These immense task has a great pay off though, which could be measured in gaining understanding in topics like:

1. What is the AGN emission mechanism?

2. What is the reason for the often observed intense variability in the galactic centre and certain classes of AGNs more than in others?

3. What is the role of the "secondary" processes (e.g. SSC, EC)? Are there any new processes that could play a role?

4. What is the role of the environment?

5. How he structural evolution relates with the variability of the spectrum.

and many more. It is therefore beyond any doubt an opportunity of invaluable importance.

Training

The suggested plan offers a wealth of opportunities for young scientists. Examples of research topics could be:

1. Multi-frequency analysis and modelling of blazars
2. Correlation between structural changes and SED variability of blazars
3. Multi-frequency variability study of Sag A*

The suggested framework on the other hand offers unlimited opportunities for theoretical studies, AGN SED modeling, variability and time series analysis as well. Even further, in technical/instrumentation field, researchers can be occupied with working on topics that have previously been mentioned. A large variety of colloquium talks, summers schools, seminars, journal clubs, conferences, a solid curriculum of courses and the expertise in training young scientists offered by the hosting institutes, guarantee a thriving environment for nourishing broad-viewed, ambitious scientists.

Summary

The proposed plan has the ambition to understand the physics of AGNs via multi-frequency and interferometric analysis. Joining our forces and expertise on a European scale with a well developed educational curriculum composed of advanced lecture series, seminars, colloquium talks of experts, thesis committees monitoring the progress and secondments between node members, provides a suitable background for such an effort to blossom.