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Studying Feedback from Super-Massive Black Holes at the center of Giant Elliptical Galaxies

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RCEU 2023 Project Proposal

Project Title

Studying feedback from super-massive black holes at the center of giant elliptical galaxies

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I. Project Description

Every galaxy with a central bulge hosts a super-massive black hole (SMBH). One of the most exciting results in astronomy recently was the finding that the SMBH mass at the center of a galaxy is related to the bulge mass of the galaxy. In other words, a SMBH, with a size of only one billionth of the host galaxy, knows its host. It is still unclear why such a correlation exists and how it was established. Many theories point out that the energy released during the SMBH growth, or feedback energy, can regulate the growth of the host galaxy. SMBHs can inject energy into their surroundings by jets and shocks and such activity can be observed in radio and X-rays.

In this project, we will focus on giant elliptical galaxies where massive SMBHs are found. We will use the warm, ionized gas with a temperature of about ten thousand K to trace the imprint of the SMBH feedback. Such gas emits Hα and other optical lines that can be effectively probed by optical spectroscopy. We will use the optical integral field spectroscopy (IFS) data from the Multi Unit Spectroscopic Explorer (MUSE) instrument on the Very Large Telescope (VLT) (https://www.eso.org/sci/facilities/develop/instruments/muse.html), which is the world-best IFS instrument!

We will study about 15 giant elliptical galaxies with the MUSE data to study the SMBH feedback in these systems. We will reduce the MUSE data with the existing pipeline and our own software. Our science goals are:

1) Produce flux and kinematic maps for the warm, ionized gas.

2) Correlate these maps with the radio emission and the X-ray emission and study their connection to study the SMBH feedback.

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties

The RCEU student is expected to work 320 - 340 hours in total for this RCEU project. The student is expected to have background on python programming and will mainly work on python codes for the project. The student will proceed the research with the following steps:
1) get familiar with the IFS data and optical spectroscopy.
2) download the MUSE data and run through the MUSE pipeline and other soft to produce the final MUSE cubes.
3) Study the underlying stellar emission and produce the stellar kinematic maps, which are required to study the emission from the warm, ionized gas.
4) Produce the flux and kinematic maps for the warm, ionized gas, after correcting for the underlying stellar emission.
5) Compare the MUSE results with radio/X-ray data to study the SMBH feedback.

b. Tangible Contributions by the Student to the Project *(10% of Review)*

This RCEU project is one component of a large multi-wavelength project. The work by the student will produce the important maps of the warm, ionized gas in these galaxies, which holds the key to study SMBH feedback and other physical processes.

c. Specific Outcomes Provided by the Project to the Student *(30% of Review)*

The student gets the opportunity to use the cutting-edge astronomical data on a hot topic in astronomy. The student will be included in any publications with the results contributed by the student. The student is also expected to present a poster on the project at a regional conference. Upon the finish of the project, the student will have real experience of astronomical research, gain a deeper understanding of galaxies and SMBHs, obtain the programming skill (particularly with python) important for the future career, and develop problem solving skills both analytically and numerically.

III. Student Selection Criteria

The successful applicant should have a good academic record (GPA > 3.4) and have finished introductory math & physics classes. The successful applicant should also have experience with python and programming.

IV. Project Mentorship *(30% of Review)*

The mentor (Dr. Sun) has a research group in the Department of Physics and Astronomy, with two postdocs and one graduate student. Both the mentor and his postdocs/graduate student will interact with the RCEU student in regular basis and provide close tutoring. Dr. Sun's postdoc Rongxin Luo is an expert on the MUSE data analysis and python programming and will interact with the student regularly. At the initial stage of the project, the student and the mentor will meet about 2 hours per day to start the project. Early start in the spring semester is also encouraged. After the initial stage, the student will work more independently, consulting with the mentor and other group members when needed, also with weekly meetings with the mentor. Office space for the student will be provided in the Optics building. Laptop and workstation access can also be provided.