1-1-2021

Studying the Structure of Giant Galaxies with the HST Data

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Proposal Identifier: RCEU21-PH-MS-02

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Project Description

Galaxies are the building blocks of our Universe. While most mass in galaxies is in dark matter, detections and studies of galaxies still rely on baryons as we still cannot detect dark matter directly — it is still essential to trace mass with light. Galaxies come with different size and mass. The hierarchical formation of the cosmic structure predicts that the most massive galaxies form the latest, thus offering important clues on galaxy formation. The most massive galaxies typically reside in dense environment like galaxy clusters. Galaxy clusters are the gravitationally bound structure of hundreds or even thousands of galaxies. They are the largest virialized structure in the Universe. First-ranked galaxies in clusters, also referred to as brightest cluster galaxies (BCGs), are the most luminous and massive galaxies in the Universe, being up to 100 times brighter than our Milky Way. Many BCGs are also characterised by an extended “envelopes” or halo over hundreds of kiloparsecs. BCGs also likely host the most massive supermassive black holes (SMBHs) in the universe, which were formed accompanying the formation of BCGs and can inject a large amount of energy into the surroundings to affect BCG evolution. The most massive galaxies in the Universe are great objects to study galaxy evolution. As each of them is the product of many mergers over its life time (to follow the so-called merger tree of the galaxy), analysis of the morphology, stellar population and the surrounding galaxy population offers hints of the merger history. The accompanied growth of the central SMBH would leave imprint on the properties of the galaxy and its surrounding medium.

In this RCEU project, we will examine a sample of 30 - 40 BCGs at the center of galaxy groups and clusters, with the data from the Hubble Space Telescope (HST). We will use several software to analyze the 2-dimensional image of the galaxy and study the internal structure, including elliptical isophotes, residual features, nuclear substructure etc. All the HST data are available from the HST archive and there can be data at multiple bands for each galaxy. Our science goals are: 1) derive good 2D isophote fits to the galaxy image and examine the variation of galaxy morphology (e.g., eccentricity, positional angle, boxy/disky components) with radius. 2) examine the residual features from e.g., dust and nuclear substructure; quantify the amount of dust from the optical data and compare with the photometry results from the far-infrared data; study the likely excess or decrement around the nucleus and explore its origin. The results from this project will play important roles in the multi-wavelength project on those galaxies.

Student Duties, Contributions, and Outcomes

The RCEU student is expected to work 320 - 340 hours in total for this RCEU project. The student will work on the pipeline products of the HST data on 30 - 40 giant galaxies. Each image is about several hundred MB. The student will proceed the research with the following steps: 1) get familiar with the HST data and download the data of 2-3 galaxies to examine first. 2) use several software: a) astropy.photutils.isophote b) iraf.Cmodel and Profiler c) GALFIT to study this initial sample to compare results. Dr Sun and his graduate students will assist the student during the process. 3)

finalize the software for the sample study. 4) extend the analysis to the full sample and summarize the results. 5) examine the residual (mostly from dust and nuclear substructure). This project is an important element in our multi-wavelength studies of these giant galaxies. The results by the student will play an important role in our future proposals and papers on this large project. The student will be included in any publications with the results from this RCEU project. 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 galaxy evolution, obtain the programming skill important for the future career, and develop problem solving skills both analytically and numerically.

Student Selection Criteria

The successful applicant should have a good academic record (GPA > 3.3) and have finished in troductory physics classes. The successful applicant should also have experience with computer programming (with e.g., python, or C) and scripting (with e.g., python, or shell). Previous experi ence with python and ds9 is preferred.

Faculty/Research Staff Mentorship

The mentor (Dr. Sun) has a large research group in the Department of Physics and Astronomy, with two postdocs and three graduate students. Both the mentor and his postdocs/graduate students will interact with the RCEU student in regular basis and provide close tutoring. Dr. Sun's senior graduate students, Will Waldron and Sunil Laudari, are experts on HST data analysis and python programming and will also interact with the student regularly. Dr. Sun's postdocs are all experienced programmers and will help to train the student in regular basis. 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.

Safety and Contingency Plan

This project does not require any lab work so can be easily adopted to the remote format if any restrictions in 2021 limit face-to-face contacts or on-campus activities. Dr. Sun has one RCEU student in the summer of 2020. With emails, zoom meetings, shared desktop and shared documents and software, it is as effective as in-person meetings.