Thomas Targett Sabbatical Report - Fall 2021 Semester
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ABSTRACT
I created a computer program which takes published numerical simulations of the early universe (less than 500 mega years after the Big Bang) and renders them as mathematically accurate projections of James Webb Space Telescope (JWST) images. These simulated images were used by members of the JWST Public Release IMaging for Extragalactic Research (PRIMER) collaboration to train galaxy detection algorithms, and determine the observational effectiveness of the telescope for deep extragalactic research. Upon the release of the Early Release Science Programs Data in the summer of 2022, these contributions merited co-authorship of the paper "The evolution of the galaxy UV luminosity function at redshifts z ~ 8-15 from deep JWST and ground-based near-infrared imaging". This paper contains the reported detection of the most-distant / earliest galaxy candidate ever observed (z~16.7)

PUBLICATION
The JWST, in less than three months of operation, has revolutionized our understanding of the early universe, exoplanet atmospheres, and star-formation. These (and future) discovers are possible given the unprecedented space-based light-collecting area, angular resolution, and near-mid-infrared wavelength coverage of the facility. For the first time, astronomers are able to measure the mass-dominant stellar-populations of the first galaxies to form in the universe, at only 2% of its present age of 13.8 Billion years. In collaboration with colleagues based at the University of Edinburgh (and other major international research institutions), we have measured the luminosity function (galaxy populations by luminosity) to unprecedented new limits, and detected a galaxy candidate at the largest distance ever measured to date (abstract follows).

"We re-reduce and analyse the available James Webb Space Telescope (JWST) ERO and ERS NIRCam imaging (SMACS0723, GLASS, CEERS) in combination with the latest deep ground-based near-infrared imaging in the COSMOS field (provided by UltraVISTA DR5) to produce a new measurement of the evolving galaxy UV luminosity function (LF) over the redshift range $z = 8 - 15$. This yields a new estimate of the evolution of UV luminosity density (ρ_{UV}), and hence cosmic star-formation rate density ρ_{SFR}) out to within < 300Myr of the Big Bang. Our results confirm that the high-redshift LF is best described by a double power-law (rather than a Schechter) function, and that the LF and the resulting derived ρ_{UV} (and thus ρ_{SFR}), continues to decline gradually and steadily over this redshift range (as anticipated from previous studies which analysed the pre-existing data in a consistent manner). We provide details of the 55 high-redshift galaxy candidates, 44 of which are new, that have enabled this new analysis. Our sample contains 6 galaxies at z>12, one of which appears to set a new redshift record as an apparently robust galaxy candidate at z~16.7, the properties of which we therefore consider in detail. The advances presented here emphasize the importance of achieving high dynamic range in studies of early galaxy evolution, and re-affirm the enormous potential of forthcoming larger JWST programs to transform our understanding of the young Universe."

NSF GRANT

Lead by Dean Elisabeth Wade in the School of Science and Technology, we obtained a $375,000 National Science Foundation (NSF) grant titled EC3, of which I am Primary Investigator (NSF Award Notice for Award ID 2225729). We proposed building a positive, supportive, and success focused cohort of students. Students entering the academic research environment for the first time can feel out of place, and URM students can dis-proportionally find themselves without a member of their family or social circles with such experience to lean on for support. By developing a peer support group, with whom participants can share their experience and derive a sense of belonging, we aim to increase retention and create a sense of belonging in STEM.

The primary innovation of this proposal is its residential nature, and focus on making the university research environment and interaction with peers central to the experience. URM students often face diversions from the undergraduate research experience typical to academia. Such cohort building is often best achieved through the more informal social interactions students can undertake during the program. While this relies on their own initiative, we propose to smooth the way by providing events such as informal lunch meetings, spaces for events such as movie nights and viewing parties, transport options for off-campus activities.

CONCLUSIONS

The publication derived from work completed during this sabbatical have resulted in an important pee-reviewed publication in a world-renown academic journal, and the successful application and award of an NSF grant. Research remains ongoing and will yield future publications, and both has/will form the basis for student research projects, allowing SSU students to participate in cutting-edge academic work. The NSF grant will work towards addressing the important issue of representation in STEM fields, by establishing a focused residential research experience at SSU.