ICA Annual report, compiled by Marcin Sawicki, Acting Director

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1. Overview

The ICA's mission is to promote the study of complex astrophysical phenomena by numerical simulation, a remit which also includes large-scale

development of new instruments and techniques; they tackle a broad spectrum of topics from the atmospheres of stars to the formation of galaxies soon after the Big Bang. These are described in the following sections (Sec. 2.1-2.5), with a focus on progress in AY2021-22. Notably, this research has resulted in 31 papers published or submitted to journals in AY2021-22 (see Section 6).

2.1. Stellar atmospheres

During AY 2020-21, Dr. Ian Short has continued to develop and test novel codes for the computational modelling and visualization of stellar atmospheres and spectra, and exoplanet transit lightcurves, and related observables, in effectively platform-independent or web-oriented programming languages such as Python, Java, and Javascript (the Chroma+ suite). The latest significant improvement to the treatment of the equation-of-state, chemical equilibrium, and ionization equilibrium solution was published in 2021 (Short, C. Ian and Bennett, Philip D., 2021, "Chroma+Gas: An Expedited Solution of the Chemical Equilibrium for Cool Star Atmospheres", Publications of the Astronomical Society of the Pacific, 133, 064501). Students in the graduate course in Stellar Atmospheres and Spectra used the code in Fall 2021 to model stellar atmospheres and spectra and to analyze the modelling results. See www.ap.smu.ca/OpenStars for additional information.

2.2. Magnetohydrodynamics of jets

Dr. David Clarke’s principal research interests include performing magnetohydrodynamical (MHD) simulations to investigate open problems in astrophysics, as well as maintaining and providing the astrophysical community with the widely-used MHD code ZEUS-3D. Dr. Clarke continues to work on the problem of stellar jets, a phenomenon associated with very early star formation. Jets are supersonic, narrow beams of magnetised gas that "proto-stars" launch along their rotation axes to very great distances (several million times their own diameters). They have profound influence both on how the proto-star evolves to a "main-sequence star" (the bulk of those we see in the night sky), and the environment in which the young stars are formed. Without jets, for example, stars as we know them could not exist, and we would not be here to discuss them

When gases attain a high enough temperature (e.g., stellar coronae), their atoms become ionised and the fluid — now known as a plasma — becomes an ensemble of charged particles. As such, a plasma is capable of generating and sustaining a magnetic field that permeates the gas, and this same magnetic field confines the charged particles in a way that particles in an ordinary gas like our atmosphere are not. The prominences from our own sun are an

Nick Martis, Robert Sorba, Johannes Zabl, together with several graduate students.

Dr. Sawicki's research interests are in the formation and evolution of galaxies, with a specific interest in their earlier evolution, the so-called "high redshift Universe". This research allows us to look back in time to when the Universe and its content were only a fraction of their present age. Dr. Sawicki's recent focus has been obtaining, processing, and analysing the large data sets ("Big Data") created in massive surveys of distant galaxies. Over the past several years much of his research time has been spent in relation to the CLAUDS survey (a major Canada-France-China observing collaboration that he leads) done with the Canada-France-Hawaii Telescope (CFHT), and its combination with the HyperSuprime-Cam Subaru Strategic Program (HSC-SSP) being taken on Japan's national Subaru Telescope by a large team of Japanese, Taiwanese, and American astronomers. Together, these two surveys probe the distant Universe to an unprecedented combination of area and depth that will be unmatched until at least the next decade. The merged CLAUDS+HSC-SSP catalogs of galaxies and stars, which were recently finalized and validated, form the foundation of a number of scientific investigations; the paper that describes them has been submitted for publication, and the catalogs themselves will be made public as soon as it is accepted by the journal. Many leading research teams from the US, Europe, and Japan have already contacted the CLAUDS team seeking early access to these data. For more information on the CLAUDS project see the CLAUDS Project Website.

A number of projects based on the merged
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behind the cluster SMACS 0723, has recently been accepted for publication by Astrophysical Journal Letters (see cover image to this report). This work has found a distant galaxy with star clusters that are almost as old as the Universe itself and that appear to contain some of the very first stars to have formed after the Big Bang.

ICA faculty member Dr. Ivana Damjanov utilizes large-area imaging and spectroscopic surveys to study the evolution of galaxies in the last 7 billion years, which corresponds to the second half of cosmic history. These studies provide crucially

of CASTOR's slitess grism spectrograph (similar to

the Chair of the Canadian National Committee for

1. The Sparkler: Evolved High-Redshift Globular Clusters Captured by JWST, Mowla, L. A., Iyer, K. G., Desprez, G., Estrada-Carpenter, V., Martis, N. S., Noirot, G., Sarrouh, G. T., Strait, V., Asada, Y., Abraham, R. G., Brammer, G., Sawicki, M., Willott, C. J., Bradac, M., Doyon, R., Gould, K., Muzzin, A., Pacifici, C.,