Onwards and upwards

If nothing else, 2021 has taught us to expect the unexpected. But what exactly are we expecting next year?

It's nearly the end of another unprecedented year. Given all the challenges that we've faced with the ongoing COVID-19 pandemic, it seems miraculous that so many large-scale projects got off the ground (no less than three Mars missions: Hope, Tianwen-1 and Mars2020, carrying the Perseverance rover and Ingenuity helicopter; Lucy mission; and a host of commercial 'space-tourism' launches).

In this final issue of 2021, we present an editorial project that has been more than one year in the making: a Collection of articles on dwarf galaxies — galaxies of mass below roughly a billion solar masses. These diminutive galaxies have emerged as key laboratories for probing the formation of the first stars and the chemical enrichment of the Universe, the growth of galaxies and the massive black holes within them, the existence and properties of dark matter, and other open questions. It is a living Collection as we will be adding to the short pieces in this issue an array of Review Articles and Perspectives on the science of dwarf galaxies, their properties and their theoretical modelling and simulations that will present the current state of knowledge of the field.

We begin with a Comment from Ignacio Trujillo on how to classify ultra-diffuse dwarf galaxies; a point/counterpoint style pair of Comments from Marcel Pawlowski and Michael Boylan-Kolchin on the issue of planes in dwarf galaxies; plus a Q&A-style Comment from Denija Crnojević and Burçin Mutlu-Pakdil in which they survey the community on what we have learned in the past two decades, where we are now both observationally and theoretically and how we will proceed in the future of this exciting research area.

2021 also saw the eventual publication of the 2020 US Decadal Survey on Astronomy and Astrophysics, which will guide the thinking for the US missions of the 2030s and 2040s. This Decadal Plan has a different flavour to most, with an increased emphasis on investment in the community, but includes a familiar exhortation to think big about flagship missions that require significant time investment, financial resourcing and technology development. As undoubtedly we will all be aware, the flagship mission of the 2000 US Decadal Plan is currently sitting on terra firma, not yet flying 20 years later.

However, later this month, hopefully, the James Webb Space Telescope (JWST) will attempt to escape Earth's gravity, carrying a payload of scientific instruments and two decades' worth of expectations. After JWST, ESA will retire the Ariane 5 rocket and test-launch Ariane 6 in the second half of 2022. Indeed, there is plenty of activity to anticipate in the new year.

In February 2022, NASA plans to take one small step for humankind to return to the Moon, with the launch of Artemis-I — its first test of the heavy-launch vehicle, the Space Launch System (SLS), and an uncrewed, partially reusable Orion Multi-Purpose Crew Vehicle. Along for the ride are 13 various CubeSats built and operated by different institutions, mounted on the Orion Stage Adaptor. They will search for ice deposits, water and other volatiles, map the lunar surface using infrared and neutron spectrometers, measure particles and magnetic fields as part of a space station, study deep-space radiation using single-celled yeast, test different propulsion systems and much more.

The Moon is set to receive even more renewed attention. The Russian space agency will continue its Luna programme after a hiatus of 46 years by sending a lander to the lunar south polar region in May (Luna-25). South Korea will be sending its first lunar mission, Korea Pathfinder Lunar Orbiter, in August. And sometime between August and November, the United Arab Emirates plans to send the Rashid rover to Lacus Somniorum near the equator. It will be onboard a Japanese lander Hakuto-R, delivered by a SpaceX Falcon 9 rocket. Furthermore, India is planning its third lunar mission, Chandrayaan-3, with a lander and rover, and NASA will deliver another two landers, the Polar Resources Ice Mining Experiment 1, or PRIME-1, and Astrobotic's Peregrine Mission 1, a commercial venture.

Going beyond the Moon, the ExoMars mission delayed from the 2020 Mars window will go ahead in September and place the Rosalind Franklin rover (ESA) and Kazachok surface platform (Roscosmos) on Mars to search for well-preserved organic material below the surface. The rover will be able to travel a few kilometres and drill down to two metres to sample. The surface platform will characterize the landing site and provide contextual information for the rover. Together they will provide a comprehensive study of chemistry and geology of the selected site, from macro down to molecular scales.

In August, a NASA orbital mission to Psyche — a small metal-rich asteroid within the asteroid belt — will aim to determine whether the surface metal represents the exposed nickel–iron core of an early planet or previously unmelted material, and how old the different surface regions are. As a secondary payload, the Janus mission will send a pair of suitcase-sized spacecraft to a pair of binary asteroids known as 1996 FG3 and 1991 VH, each consisting of a primary asteroid and a moon, to capture surface images and track their dynamics. Janus will be the smallest science mission in the history of NASA's Planetary Science Division.

Putting to one side the planetary science prospects for the year, it will also be a big year for astrophysics. JAXA will launch the XRISM mission, containing an X-ray telescope that will perform high-resolution spectroscopic observations of the hot plasma wind that blows through galaxies. ESA's Gaia mission has been revolutionizing stellar astrophysics since 2014, and plans to release its third dataset in its entirety to the community in the first half of 2022. By the end of the year, JWST should be producing science data: 460 hours of Early Release Science that will be made public immediately, 4,000 hours of Guaranteed Time Observations and approximately 6,000 hours of General Observer time. Much of the information will be unique, so we can reasonably expect the unexpected. The next 12 months will be full of anxious expectation for many, but we've waited 20 years for the successor to Hubble and Spitzer, surely we can wait patiently for one more? ❐

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