

Astronomy in Ireland

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Astronomy has been very important in Ireland since ancient times. In the Victorian era, the country had not only the largest reflector in the world, but also the largest refractor. Modern astronomical research is concentrated in various Irish universities as well as the Dublin Institute for Advanced Studies. Astronomy is very popular among the public at large, and also as a means of promoting graduate uptake in Science, Technology, Engineering and Mathematics (STEM). After providing some historical background, we give a broad-brush review of astronomical research in the country with the intention of encouraging collaboration with Ireland, the newest member of the ESO family.

Interest in astronomy in Ireland can be traced back over 5000 years. The pre-Celtic inhabitants built magnificent structures such as those in the Boyne Valley northwest of Dublin long before the pyramids — and even Stonehenge — were constructed. One in particular, at Newgrange, is renowned for marking the winter solstice sunrise. For a few days either side of the shortest day of the year, light from the rising Sun shines through the roofbox above its entrance, traverses a 20-metre long passage, and illuminates the main chamber inside the giant mound. The precision achieved is remarkable when one considers that the alignment is



Figure 1. The so-called Sundial Stone decorates one of the mounds at Knowth in the Boyne Valley and dates back 5000 years. Interpreting such art is notoriously difficult but there is little doubt that nearby Newgrange was deliberately aligned with sunrise on the winter solstice.

perfect for when the monument was built 5200 years ago. The tilt of the Earth at that time was 24 degrees as opposed to its current 23.5 degrees. To witness the phenomenon now, one has to wait roughly 10 minutes after sunrise for the light to shine into the chamber, whereas

then it would have been visible directly at sunrise. Moreover, back when it was built, sunlight would have penetrated to just touch the back wall of the monument; the Neolithic people who constructed Newgrange had solved a 3D astronomical puzzle.



Peter Gallagher, DIAS

Figure 2. Historic Birr Castle is not only the site of what was the largest telescope in the world for many years, the Leviathan, but also the location of Ireland's LOFAR station (I-LOFAR) which operates as part of the international LOFAR facility. I-LOFAR is managed by a consortium of Irish research institutes led by TCD and DIAS.

In more modern times, Ireland was, for a brief period during the Victorian era, home to not only the largest reflector in the world, the so-called Leviathan at Birr Castle in County Offaly, but also the largest refractor at Markree Castle, County Sligo. The Leviathan, with its six-foot (1.83-metre) mirror, is no doubt the better known instrument — Lord Rosse used it to discover and subsequently name such famous objects as the Crab and Whirlpool nebulae. This interest in astronomy in Ireland during the 19th century also gave rise to a major industry: telescope making. Founded in Dublin by Thomas Grubb, and subsequently managed by his son Howard, the firm of Grubb manufactured some of the largest telescopes in the world, such as the Great Refractor of the Vienna Observatory and the Great Melbourne Telescope. Howard Grubb also made eclipse instruments which proved crucial in testing Einstein's general theory of relativity, 100 years ago.

Ireland is also the place where the first photoelectric experiments were performed by Stephen Mitchell Dixon and William Stanley Henry Monck. At Monck's observatory in the centre of Dublin, the relative brightness of Venus and Jupiter was recorded in 1892 using a simple photoelectric cell made by George Minchin. This was followed a few years later by the earliest such measurements of stars at William Wilson's observatory in County Westmeath, not far from Dublin.

The two oldest purpose-built observatories in Ireland are located in Dunsink, close to the centre of Dublin, and its sister establishment in Armagh. Dunsink, which was founded as part of Trinity College Dublin in 1785, was home to Ireland's most famous mathematician,

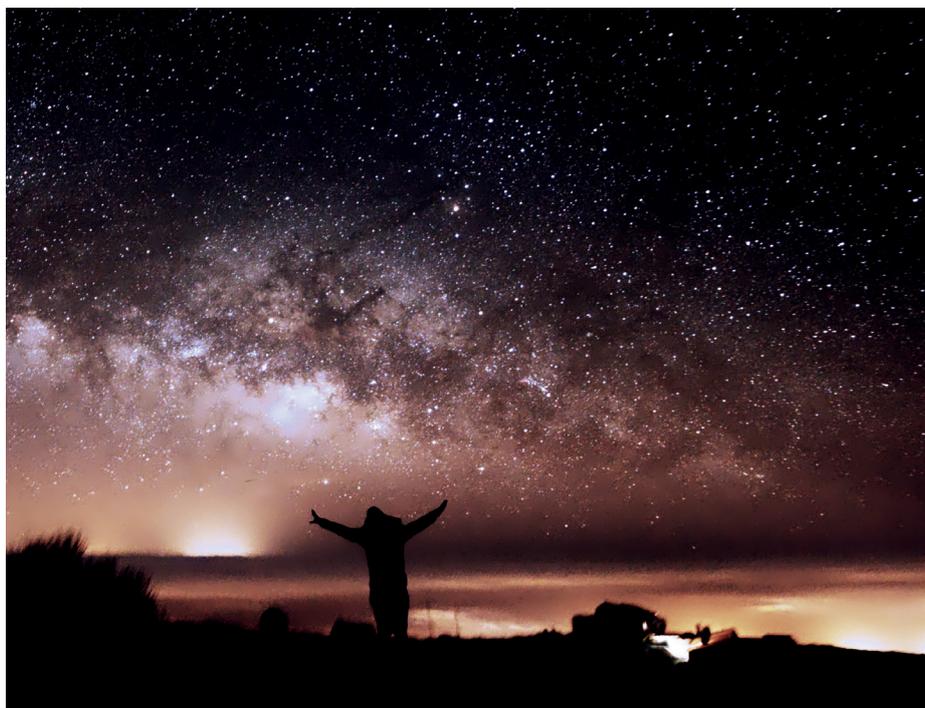
William Rowan Hamilton. Work at the observatory centred on using stars to measure time but it was also the site of some of the earliest attempts at determining stellar parallaxes.

The modern astronomical era in Ireland can be said to have begun in 1947 with the acquisition by the Irish State of Dunsink Observatory as part of the fledgling Dublin Institute for Advanced Studies — at that time headed by the well-known physicist Erwin Schrödinger. The importance of accessibility to remote sites to carry out serious astronomical research

was glaringly obvious. As a result of an initiative from Eric Lindsay, then Director of Armagh, Ireland initially had access to astronomical facilities at Bloemfontein (South Africa) through an international treaty involving Armagh, Dunsink and Harvard (USA). Eventually this was replaced by the use of the telescopes at the La Palma Observatory (Spain) under an agreement between the Irish National Board of Science and Technology and the then Particle Physics and Astronomy Research Council in the UK.

Today, Physics with Astronomy is offered as a degree course at several Irish universities. High-tech industry is a very important component of the modern Irish economy and the role of astronomy in promoting STEM (science, technology, engineering and maths) as a career choice is increasingly acknowledged.

Ireland was a founding member of the European Space Agency and this has led to its involvement in many well-known science missions, such as the ESA INTERnational Gamma-Ray Astrophysics



Antonio Martin-Carrillo

Figure 3. Undergraduate students from UCD undertake an astronomy observing field trip to a professional observatory in their final year.

Laboratory (INTEGRAL) and the Herschel Space Observatory, as well as a number planned for the future like Solar Orbiter and the James Webb Space Telescope. Ireland is looking forward to participating fully in ESO as its newest Member State. Public engagement in astronomy is certainly very strong in the country, with one of the highest *per capita* memberships of amateur astronomical societies in Europe. Here we provide just a flavour of the main astronomical interests in our research establishments as a basis for possible collaboration with other members of the ESO community.

- **The Dublin Institute for Advanced Studies (DIAS)** primarily conducts research into star formation and solar physics although it also retains an interest in high energy astrophysics. As an example, it manages the country’s involvement in the High Energy Stereoscopic System (HESS) based in Namibia as a facility for gamma-ray astronomy. In the past few years DIAS has created a new astronomical detector group concentrating on optical/near-infrared Microwave Kinetic Inductance Detectors (MKIDs). Before joining ESO, the institute was already a partner in a number of astronomical projects in Chile, such as GRAVITY on the Very Large Telescope Interferometer (VLTI). DIAS is playing a leading role in the Mid-Infrared Instrument (MIRI) on the James Webb Space Telescope (JWST) and on the ARIEL Space Mission, which will explore exoplanet atmospheres.

- **Trinity College Dublin (TCD)** is Ireland’s oldest university and has a vibrant astrophysics research programme covering theoretical and observational aspects of exoplanets, low-mass and massive stars, supernovae, electromagnetic counterparts of gravitational wave events, and light pollution studies. TCD Astrophysics has five faculty members who have leading roles in international consortia for the JWST and Colorado Ultraviolet Transit Experiment (CUTE) space missions (the latter being an ultraviolet spectroscopy mission to study exoplanet atmospheres), as well as a number of large ESO-related projects such as the NTT transient follow-up programme (e)PESSTO, the VLT gravitational wave follow-up programme



C. O’Sullivan, Maynooth University

Figure 4. The ground-based cosmic microwave background (CMB) instrument called the Q&U Bolometric Interferometer for Cosmology (QUBIC) being integrated in Paris before being shipped to its observing site in Argentina. The QUBIC optics were designed by the Maynooth team.

ENGRAVE, and the 4-metre Multi-Object Spectroscopic Telescope (4MOST), a future spectroscopic survey instrument for VISTA. TCD builds on a strong Irish heritage in astronomy. The current TCD Astrophysics group runs undergraduate and postgraduate programmes in physics and astrophysics, with about 20 students graduating per year and growing numbers of postgraduate opportunities. It is anticipated that the existing use of ESO facilities will expand further in the next few years and bolster research opportunities.

- **Dublin City University (DCU)** is one of the country’s newest universities, and consistently features as one of the top young universities worldwide. About 15 students graduate every year from its Physics & Astronomy degree programme. DCU hosts the Centre for Astrophysics & Relativity¹ (CfAR), com-

prising eight faculty members drawn from the School of Physical Sciences and the School of Mathematical Sciences. There are particular research strengths in observational astronomy, computational astrophysics and general relativity. Current research topics range from exoplanets and weakly ionised astrophysical plasmas to high energy astrophysics, supermassive black holes, gravitational waves and mathematical relativity. Before Ireland joined ESO, DCU collaborated extensively in the use of its facilities and anticipates that such collaborations will increase in the coming years.

- **University College Dublin (UCD)** has a distinguished tradition in astrophysics, starting from pioneering work in the 1960s on the development of ground-based high-energy gamma-ray astronomy. Astrophysics continues to



Figure 5. Crawford Observatory, University College Cork.

be a vibrant research area, with about 20 staff, researchers and postgraduate students. UCD astronomers are leading research on a wide range of topics, including the search for and characterisation of galactic and extragalactic very high-energy gamma-ray sources with the VERITAS telescope array, the Cherenkov Telescope Array (CTA), astrophysical jets with the LOw-Frequency-Array (LOFAR), pulsar timing, shock acceleration theory, gamma-ray bursts and other transients detected by

NASA's Swift and Fermi missions and ESA's INTEGRAL and XMM-Newton satellites, progenitors of supernovae and tidal disruption events, terrestrial gamma-ray flashes, development of novel scintillators and gamma-ray detectors, CubeSats, robotic telescopes, electromagnetic counterparts to gravitational wave sources, data mining astrophysical transients, star and planet formation research with the Hubble Space Telescope, the future ARIEL space mission to characterise

exoplanet atmospheres, ESO's VLT and VLTI telescope facilities, the Gemini telescopes and ALMA. Development of the Educational Irish Research Satellite (EIRSAT-1) — Ireland's first satellite — is being led by UCD astrophysics students and staff. The mission will fly innovative Irish technology in space, including a new detector to observe gamma-ray bursts. Annually, 12–15 BSc students graduate from the Physics with Astronomy & Space Science programme, and about the same number of MSc students graduate from the Space Science & Technology programme.

- **Maynooth University (MU)** offers an undergraduate degree in Physics with Astrophysics and postgraduate research degrees in Astrophysics at Masters and PhD level. Research is carried out by two groups in the Department of Experimental Physics. The Space Terahertz Optics group has internationally-recognised expertise in millimetre-wave optics, electromagnetic instrument qualification and astronomical observation. They have been core team members of a number of important astronomical projects including ALMA, the High Frequency Instrument (HFI) on the ESA Planck Surveyor and the Heterodyne Instrument for the Far-Infrared (HIFI) on the Herschel Space Observatory. The star and planet formation group has expertise in high angular resolution and spectroscopic observations of outflow and accretion activity in young stars and brown dwarfs. The group is involved in several international collaborations and primarily works in the optical and near-infrared regimes using ESO facilities.

- **The National University of Ireland Galway (NUI Galway)** was established in 1845 and is the leading higher education and research organisation in the west of Ireland. The Centre for Astronomy (CfA) hosts one of the largest collections of astrophysics researchers in Ireland, and members of the centre carry out research in astronomy, astronomical instrumentation and computational astrophysics. Research topics include applied imaging, adaptive optics, clusters and exoplanets, gamma-ray astronomy, high speed Stokes polarimetry, pulsars, star formation and

astrochemistry, ultra-cool stars, and astro-informatics. CfA astronomical instrumentation researchers designed and built the Galway Astronomical Stokes Polarimeter (GASP), which has had two recent runs on the ESO 3.6-metre telescope at La Silla. Another visitor instrument built here was the Galway High Speed Photometer (GUFI) at the Mount Graham Observatories. NUI Galway also houses the Irish Centre for High-End Computing (ICHEC) which is extensively used by Irish astrophysicists carrying out numerical simulations. A new MSc programme, Astronomical Instrumentation and Technology, had an intake of six students in 2018 and is steadily growing.

– **University College Cork (UCC)** can trace its heritage in astronomical research back to 1880, with the construction of the Crawford Observatory (which included instruments made by Howard Grubb, mentioned above) on the university campus (see Figure 5). Astrophysics research in UCC is focused on three core themes, involving: (i) multi-wavelength observations of cataclysmic variable and X-ray binaries;

(ii) Very Long Baseline Interferometry (VLBI) and polarisation studies of active galactic nuclei; and (iii) theoretical high-energy astrophysics (including relativistic plasma astrophysics and radiative transfer problems as applied to gamma-ray bursts). The group is involved in ESA's Athena X-ray mission and the proposed Theseus M5 mission.

– **Cork Institute of Technology (CIT)** operates the Blackrock Castle Observatory² (BCO) which houses an internationally award-winning science centre focusing on astronomy and space science; this was opened to the public in 2007. The objective of the BCO is to use astronomy and space science to enthuse visitors, young and old, about the benefits of science and critical thinking. More recently, the observatory has acted as an advocate for Ireland's involvement in space. BCO welcomes around 105 000 visitors annually, with an additional 10 000 pre-university students engaged in formal and informal workshops. The observatory also operates as the ESO Science Outreach Network point of contact for Ireland. Research at BCO

concentrates on small robotic observatories and high-speed photometry, which aims to minimise the negative effects of atmospheric turbulence on photometric measurements.

Finally, it should be mentioned that the professional organisation for Irish astronomy is the Astronomical Sciences Group of Ireland (ASGI), which was founded in 1974. It is a cross-border organisation with members in both Ireland and Northern Ireland, and is affiliated to the European Astronomical Society. The ASGI hosts the annual Irish National Astronomy Meeting each September, which attracts up to around 100 delegates, with a particular emphasis on encouraging talks from postgraduate researchers.

Links

¹ Centre for Astrophysics & Relativity (CfAR): www.cfar.ie

² Blackrock Castle Observatory: www.bco.ie



Figure 6. Blackrock Observatory in County Cork. This is largely used as an outreach facility to promote astronomy to a broad audience.