The Case for Irish Membership of the European Southern Observatory

Prepared by the Institute of Physics in Ireland
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IOP | Institute of Physics in Ireland

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Summary

The European Southern Observatory (ESO) is universally acknowledged as being the world leading facility for observational astronomy. The astrophysics community in Ireland is united in calling for Irish membership of ESO believing that this action would strongly support the Irish government's commitment to its STEM (science, technology, engineering and maths) agenda.

An essential element of the government's plans for the Irish economy is to substantially grow its high-tech business sector. Physics is a core part of that base, with 86,000 jobs in Ireland in this sector[1] while astrophysics, in particular, is a key driver both of science interest and especially of innovation. To support this agenda, Irish scientists and engineers need access to the best research facilities and with this access comes the benefits of spin-off technology, contracts and the jobs which this can bring. ESO is currently expanding its membership to include Brazil and is considering some eastern European countries. The cost of membership will increase as more states join and as Ireland's GDP increases. Significantly ESO is set to begin its most ambitious programme to date – the €1 billion European Extremely Large Telescope which will bring both exceptional technical challenges and with it the opportunity for member states to bid for highly valuable contracts. Hence the time is never been more opportune to join ESO.

Membership of ESO would bring significant rewards to Ireland including:

1. Give Irish researchers guaranteed access to its facilities and allowing Ireland to compete at the highest international levels and to align its research strategies with those of Europe – thus optimising Ireland's chances of success in Horizon 2020.
2. Give Irish businesses the chance to compete for multi-million euro contracts across a wide range of technologies including imaging, detectors, computing and micro-electronics.
3. Give Irish students outstanding opportunities for training.
4. Greatly enhance public awareness and understanding of science across a range of disciplines.

In the drive to ensure Ireland's position in the global knowledge economy, the Institute considers membership of ESO to be critical.

European Southern Observatory Overview

La Silla Observatory in Chile, which has three telescopes built and operated by ESO and several other telescopes managed by ESO member states. The locations of La Silla and the other ESO observatories, at high locations in the Atacama Desert far from sources of light pollution, are ideal for astronomical observations. (Credit: ESO/José Francisco Salgado)

The European Southern Observatory is an intergovernmental European organisation for astronomical research and is widely regarded as the best astronomical observing facility in the world.[2] Significant discoveries at ESO include the plotting of orbits of stars around the central black hole in our galaxy, and the first-ever image of a planet outside our solar system.

ESO consists of a suite of telescopes located in the high Andes of Chile giving access to research in infrared, optical and radio wavelengths. It currently has 15 member states[3] and has its headquarters near Munich in Germany.

It brings together the very highest calibre of scientists with expertise spanning many areas of science and technology. It is also a significant driver and consumer of advanced technology, generating large industrial R&D contracts and spin-offs for its members.

European Southern Observatory Overview continued

Case Study

NUI Maynooth input to design of the Atacama Large Millimeter/ submillimeter Array (ALMA)

At NUI Maynooth, the main focus of astrophysics research is in optics in the far-infrared/THz band. In recent years members of the department have been core team members of the European Space Agency missions Planck and Herschel as well as on working groups for a number of proposed missions. Researchers at Maynooth have also been involved in ground-based cosmic microwave background projects. They collaborated with the Space Research Organisation of the Netherlands (SRON) on the design of the Atacama Large Millimeter/submillimeter Array (ALMA) band 9 receivers. ALMA construction and operations are led on behalf of Europe by ESO.

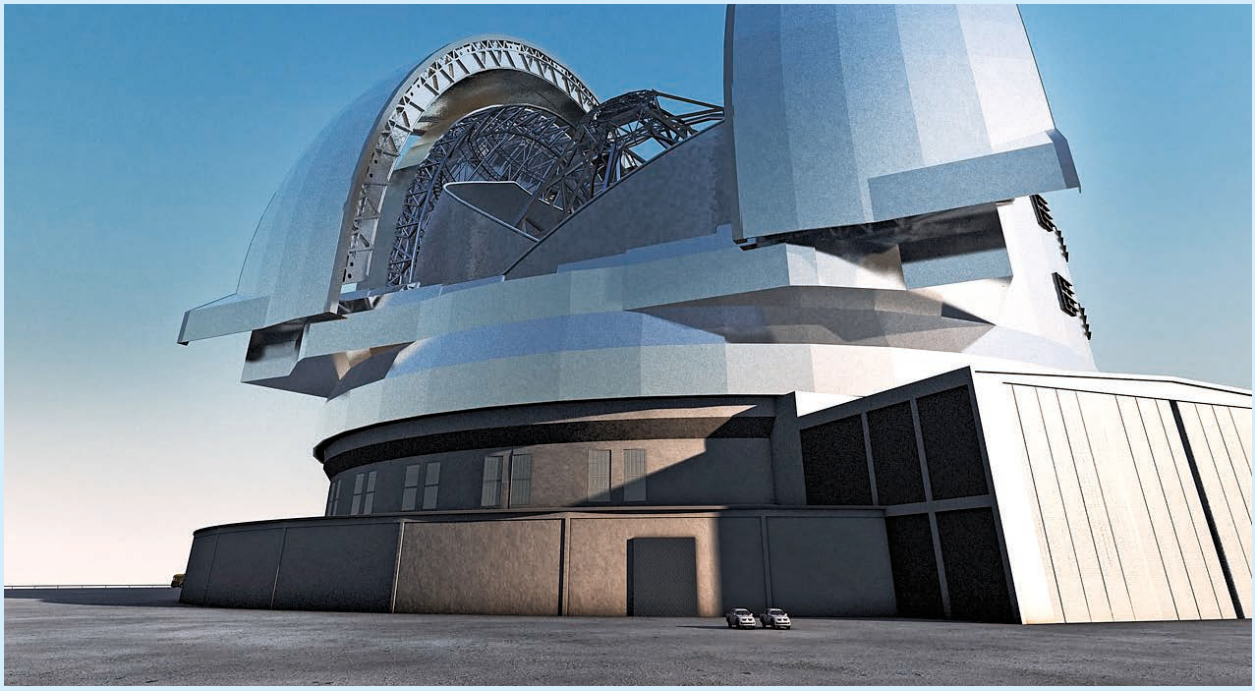
Its current flagship instrument is the Very Large Telescope (VLT) which is the world's most advanced optical instrument, consisting of four Unit Telescopes with main mirrors of 8.2m diameter and four movable 1.8m diameter Auxiliary Telescopes. The telescopes can work together, to form a giant 'interferometer', allowing astronomers to see details up to 25 times finer than with the individual telescopes. The light beams are combined in the VLT Interferometer (VLTI) using a complex system of mirrors in underground tunnels where the light paths are kept to an accuracy of one hundredth of the thickness of a human hair over a hundred metres. With this kind of precision the VLTI can reconstruct images with an angular resolution of milliarcseconds, equivalent to distinguishing the two headlights of a car at the distance of the Moon.

Other high level instruments at ESO include the Atacama Large Millimetre Array (ALMA), which began operations in 2013. ALMA is an international partnership comprising ESO and partners in the USA and Japan and is based at the Chajnantor plateau at an elevation of 5km – one of the highest observatory sites on Earth. It will push the boundaries between radio and optical astronomy and required significant technological developments in antenna design, high frequency radio detection and robotic operation at high altitude.

ESO is the most productive observatory in the world. In 2013 alone, over 840 refereed papers based on ESO data were published. Moreover, research articles based on data from the VLT are in the mean quoted twice as often as the average.

It is clear that the suite of observing facilities available at ESO is both powerful and diverse, and is considered by Irish astrophysicists to provide an excellent match to Irish astronomical research strengths.

European Extremely Large Telescope



Artist's impressions of the European Extremely Large Telescope (E-ELT), to be built by ESO at Cerro Armazones in northern Chile. (Credit: ESO)

ESO's next major project is the construction of the European Extremely Large Telescope (E-ELT). It is a revolutionary scientific project for a telescope with a mirror of roughly 40m in diameter that will allow scientists to address many of the most pressing unsolved questions about our Universe.

The E-ELT will be the largest optical/near-infrared telescope in the world and will gather 13 times more light than the largest optical telescopes existing today. It will be able to correct for the atmospheric distortions (i.e. fully adaptive and diffraction-limited) from the start, providing images 16 times sharper than those from the Hubble Space Telescope. The E-ELT will vastly advance astrophysical knowledge by enabling detailed studies of planets around other stars, the first galaxies in the Universe, super-massive black holes, and the nature of the Universe's mysterious dark constituents.

To achieve these ambitious goals, ESO is constantly developing new instruments and technologies, while simultaneously taking the lead in ICT developments particularly in sophisticated analysis software. It requires cutting edge technology in such areas as detectors, high-speed micro and opto-electronics, high-performance computing, high-speed networking, large volume data storage, mechanical and electrical engineering – all areas with tremendous potential for technology transfer and industrial spin-offs in Ireland.

Summary of ESO Telescopes and Instrumentation

Paranal Observatory

The Very Large Telescope (VLT) at Cerro Paranal is ESO's premier site for observations in the visible and infrared light. All four Unit Telescopes (UTs) of 8.2 metres diameter operate individually using a large collection of instruments

Two telescopes for imaging surveys are also in operation at Paranal, the VLT Survey Telescope (VST, 2.5 metre diameter) for the visible and the Visible and Infrared Survey Telescope for Astronomy (VISTA, 4.1 metre) for the infrared.

La Silla Observatory

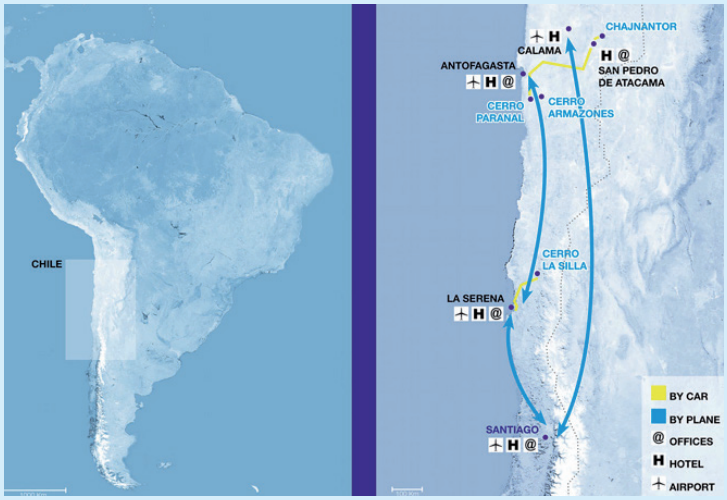
ESO operates two major telescopes (the ESO 3.6-metre telescope and the New Technology Telescope (NTT) at the La Silla Observatory. They are equipped with state of the art instruments either built completely by ESO or by external consortia, with substantial contribution by ESO.

APEX

APEX, the Atacama Pathfinder Experiment is a collaboration between Max Planck Institut für Radioastronomie (MPIfR) at 50%, Onsala Space Observatory (OSO) at 23%, and the European Southern Observatory (ESO) at 27% to construct and operate a modified ALMA prototype antenna as a single dish on the 5100-metre high site of Llano Chajnantor.

ALMA

The Atacama Large Millimeter/submillimeter Array, or ALMA, is an international collaboration to develop a telescope of revolutionary design to study the Universe from a site in the foothills of Chile's Andes Mountains. ALMA is composed of 66 high precision antennas, operating at wavelengths of 0.32 to 3.6 mm. Its main 12-metre array has fifty antennas, each 12 metres in diameter, acting together as a single telescope.



Location of the 4 ESO sites (blue text) in Chile. (Credit: ESO)

E-ELT

ESO has been working together with its user community of European astronomers and astrophysicists to define the new giant telescope needed by the middle of the next decade: the European Extremely Large Telescope (E-ELT). The E-ELT will be based at the Cerro Armazones, 20 kilometres from Paranal, site of the VLT and will be the largest optical/near-infrared telescope in the world: the world's biggest eye on the sky. The 39m mirror stretches over almost half the length of a soccer field.

Technology Development at ESO

Case Study

TCD studies of cold molecules using ALMA

While NUI Maynooth has focussed on the development of new instrumentation, including ALMA, the research group at Trinity College Dublin which focusses on solar and stellar astrophysics has had a programme accepted to use the high angular resolution and very high flux sensitivity of ALMA to make a detailed study of cold molecules in space and the presence of faint dust emission near the bright star Betelgeuse. This work is to address the link between molecules and dust formation, a major unanswered question in stellar astrophysics that is important for the birth of new stars as well as, potentially, the formation of planetary systems. The project utilises the combination of high sensitivity and high resolution in the millimetre/sub-mm band that is only now possible with the ALMA instrumentation, and combines data from ALMA with data from the NASA/ESA Hubble Space Telescope to constrain and test theoretical models in detail for the first time.

ESO is heavily involved in many aspects of cutting edge technology development in fields such as active and adaptive optics, fibre lasers, Virtual Observatories, dynamic scheduling software, instrument interfaces, data archiving/mining, and automated data reduction pipelines. ESO actively promotes technology transfer into the broader economy and there are many examples of ESO developments that have been taken over by a manufacturer or produced commercially for a wider market including liquid nitrogen cryostats for charge-coupled devices (CCDs), flexible mirrors and infra-red detectors. These are all areas in which Ireland has significant strengths. As examples, applied optics researchers at NUI Galway are world leaders in the 'adaptive optics' that are required for modern telescope mirrors, N. Ireland based Andor Technologies construct CCDs while SensL and the Tyndall Institute are researching and developing the technologies required for the next generation of near infrared detectors. Many examples of technologies that have been developed or extended in collaboration with industry through an ESO development contract and subsequently used in the wider commercial environment are described by ESO at

http://www.eso.org/public/industry/techtrans/DevelContract.html#volume.

Adaptive optics are used to remove the 'twinkle' of a star caused by atmospheric distortion to create clearer images. The same technique is now being used by researchers in Galway to find cures for diseases in the human eye.

Big Data and Energy-Efficient Computing

The new deformable secondary mirror for the Adaptive Optics Facility under test at ESO in Garching, Germany. (Credit: ESO)

In recent years the complexity of computing needs world-wide has become a highly important issue for business with enormous growth in the amount of data available.

A recent Forfás report[4] looked at how to build up the big data and analytics talent pool in line with enterprise demand. The report notes that globally, there is a shortage of data analytics talent particularly of individuals with the required 'deep analytical' skills. Current government policy aims to position Ireland as the leading country in Europe in this area. However, this will require sustained action to train, retain and attract people with the necessary skills.

Astrophysics is driving significant development in this area because of the huge data sets which require high performance and efficient computing capabilities and ESO, in particular, is leading the way.

ESO telescopes collect data at unprecedented rates. In 2003, for example, the amount of science data collected from the ESO Observatories was about 10 Terabytes per year. In 2013 this figure rose to 250 Terabytes per year. This increase is considerably higher than the rate of increase in computing processing power that has to process it. The ESO Next Generation Archiving System (NGAST) has been developed to overcome these problems and ESO scientists and engineers are in considerable demand for their skills in this area.

Return to Industry

ESO has an annual procurement budget of €120 million and this amount is set to increase significantly with the construction of the E-ELT. ESO procurement covers all areas of goods and services needed to design, construct and operate astronomical observatories and ranges from basic and general services to electronics, mechanics, IT, optics, vacuum and cryogenic technologies. Additionally, ESO awards contracts for feasibility studies in support of its development programme.

It is also likely that there will be further VLT third generation instrumentation contracts. If Ireland were to delay joining ESO the potential industrial return would be lost.

Three of the four 8.2-metre telescopes of the Very Large Telescope array (VLT) at Cerro Paranal in Chile. (Credit: ESO)

Procurement at ESO is based on the principle of competitive tendering. Bids are accepted from companies in Member States and Chile (the latter for operations). ESO does not operate a *juste retour* policy, but nonetheless, Members States have a strong expectation of an equitable distribution of contracts. Therefore, the Member State *return coefficients* are monitored by ESO and reported to the ESO Council and Finance Committee on a yearly basis. ESO aims to achieve a medium-term equitable distribution of contracts and can apply a number of instruments in this regard to assist 'under-returned countries'.

> As an indicator of possible returns, Austria, which as similar GDP/capita as Ireland – obtained ESO contracts totalling at least €7 million since joining in 2009.

These instruments include:

- Close monitoring + regular reporting to the ESO's relevant governing bodies;
- Strong involvement of Industrial Liaison Officers in the Member States in identifying possible suppliers;
- Industry days and networking events;
- Restricted Calls for tender (only for 'under-returned countries').

The goal for ESO, is to achieve an industrial return ratio of at least of 0.7 for each Member State and it works closely with government agencies to promote opportunities to bid for contracts. Details of how ESO engage with industry through procurements, industry events, etc. are described more fully at *www.eso.org/public/industry*.

As an example, Austria, which has a similar GDP per capita as Ireland, (approximately US$36,300[5]) has been awarded industrial contracts worth at least €7 million since joining in 2009.[9]

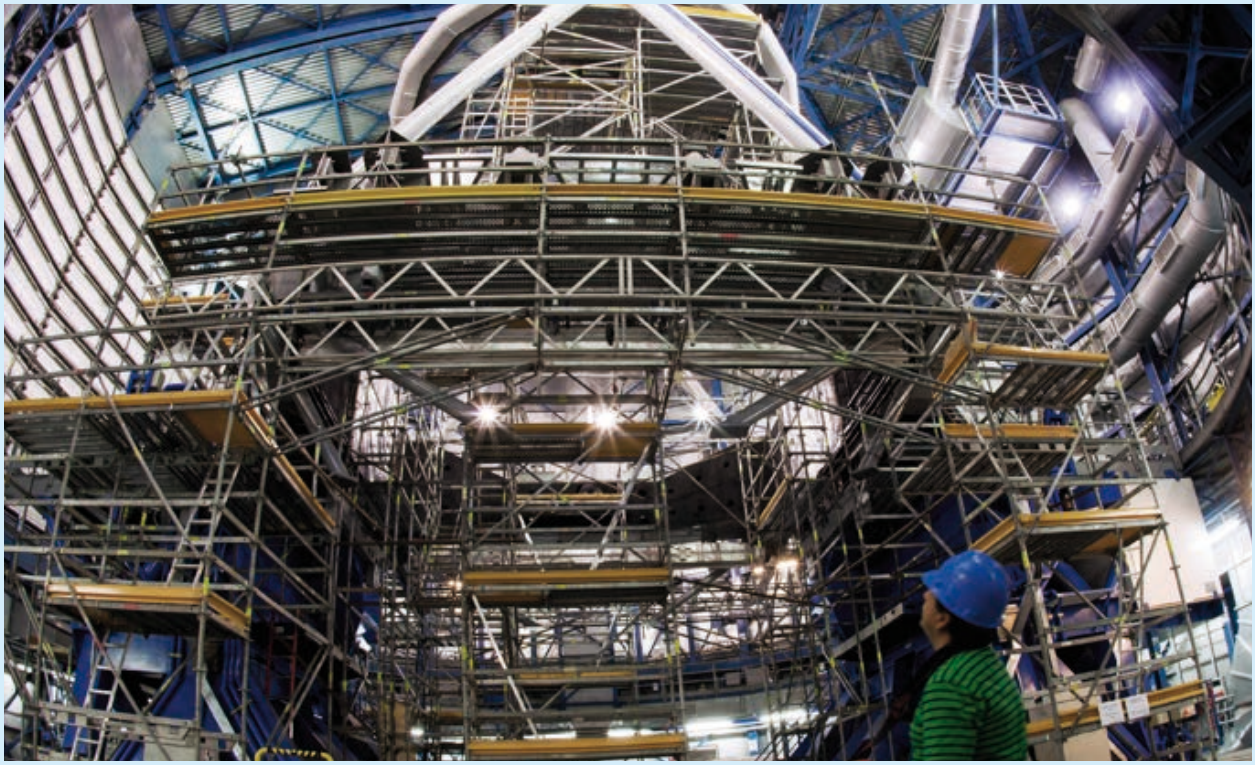
Ireland and Space Technologies

Several of the 66 antennas of the Atacama Large Millimeter/submillimeter Array (ALMA) located at Chajnantor in Chile. (Credit: ESO/C. Malin)

Every euro invested in space technology usually turns out to produce 6-7 euros in overall economic return.

Ireland has been a member of the European Space Agency since 1975. Astrophysicists throughout Ireland have made significant contribution to the development and design of a range of ESA programmes often working with Irish and international businesses to achieve this. This has ensured that Ireland has a significant space technologies industry sector as evidenced by the return from Irish membership of the European Space Agency[6].

Enterprise Ireland is skilled in identifying opportunities and matching companies to contracts as proven from Ireland's exceptional success in obtaining contracts with the European Space Agency. Over 80 Irish firms have won ESA contracts worth an estimated €80 million since 2000 while the level of spin-off export sales (including direct ESA contracts) from Irish investment in ESA was around €35 million in 2010. There is also a significant multiplier effect with these contracts. ESA notes that every euro invested in its space technology usually turns out to produce 6-7 euro in terms of the overall return to economic activity.[6]



Upgrade work in preparation for the installation of the Adaptive Optics Facility on Unit Telescope 4 of ESO's Very Large Telescope array (VLT). (Credit: ESO/G. Blanchard)

Annually Irish companies successfully tender for around 20-30 contracts each year with around four new companies getting involved each year. However it is likely that Ireland is reaching its capacity for contracts from ESA and so these companies will be seeking new opportunities.

Ireland's success in bidding for ESA contracts augers extremely well for the return it is likely to obtain from ESO membership, as the technical expertise required by these organisations is similar.

ESO particularly engages businesses in the fields of communications, electronic components, precision engineering, software development and analytic services. Captec is a good example of an Irish company that has had considerable success with ESA contracts. Captec provides high reliability critical software and related services. It has established a leadership position in the successful development of on-board satellite software for the European space industry. In the field of sub-mm and mm technology on which ESO's ALMA project is based, Farran Technology designs and manufactures a wide range of components and subsystems using state of the art waveguide technology.

Ireland and Space Technologies continued

Case Study

NUI Galway and Adaptive Optics Research

The applied optics research group at NUI Galway are world leaders in the adaptive optics technologies that are a key component of modern observing facilities and NUI Galway would be well positioned to make strong bids for E-ELT research contracts. A recent major conference at NUI Galway, 'Speed and Sensitivity' (sponsored in part by Science Foundation Ireland and Andor Technologies), explored science drivers, technological developments and novel instrumentation specifically applied to the E-ELT. Research into star formation would be boosted by full access to the ALMA, while supernovae and other star destruction processes can be observed by the VLT. Pulsars, which result from supernova explosions can be investigated by an instrument such as the SFI-funded Galway Astronomical Stokes Polarimeter (GASP). Membership of ESO would open the possibility to place GASP onto one of the VLT telescopes to further boost the scientific returns from this instrument. Finally, as the home of the Irish Centre for High End Computing, NUI Galway would be in a position to bid for Big Data and Virtual Observatory contracts offered by ESO.

Physics based businesses such as these contribute more than €7 billion to the Irish economy, or 5.9% of total economic output. In total these business employ over 86,000 staff which is comparable to that of all of the finance, banking and insurance sectors combined. Including induced and indirect sectors, employment rises to 205,000 and the Gross Value Added (GVA) contribution to €12 billion.

> Turnover per employee in the physics-based European sector averaged €240,000 per annum – almost twice the equivalent figure for the construction industry.[7]

This business sector exports more than €23 billion of goods and services annually. As a proportion of turnover they have consistently exported more than the national average: 45% in physics-based businesses, compared with the national average of 41%.[1]

Europe-wide studies[7] of this sector also note that for every €1 increase in physics-based output, the economy-wide increase in output is €2.28 within the EU27 countries. Additionally turnover per employee in the physics-based European sector averaged €240,000 per annum – almost twice the equivalent figure for the construction industry.

Clearly it makes considerable economic sense to invest in physics.

Astrophysics and Ireland

The second of three images of ESO's GigaGalaxy Zoom project is a new and wonderful 340-million-pixel vista of the central parts of our galactic home. (Credit: ESO/S. Guisard)

Astrophysics is a particular strength in Irish research with nearly 200 researchers working in this area across nine colleges. Research areas include many aspects of space technology and astrophysics, with projects ranging from the construction of satellite missions to the exploration of galaxies. For example at University College Cork, scientists are exploring white-dwarfs, neutron stars and black hole binaries using infrared, optical and X-ray telescopes while astronomers at the Dublin Institute of Advanced Studies are investigating how stars like the Sun form using optical, infrared, millimetre and radio facilities.

Some of this research has has included work at ESO which has been achieved through linkages with other international research groups. Irish scientists are already working on instrumentation options for the E-ELT. However such options are extremely limited without Irish membership of ESO.

Astrophysics and Ireland continued

Case Study

Dublin Institute for Advanced Studies – How did the Sun and planets form?

The Star Formation Group at the Dublin Institute for Advanced Studies (DIAS) has been studying the birth of stars like the Sun for a number of years. It is remarkable to think that a decade ago we knew more about the first 3 minutes of the Universe than we did about the first 3 million years in the life of our own Solar System. This has, however, changed with the development of new astronomical facilities, particularly at infrared and longer wavelengths, that have allowed us to penetrate the thick cloud of gas and dust surrounding newborn stars.

It is also currently involved with the development of software for GRAVITY, the next generation interferometer for the Very Large Telescope (VLT) and is part of the consortium which built the Mid-Infrared Instrument (MIRI) for the James Webb Space Telescope (JWST) by virtue of Ireland's membership of ESA. As a result it will receive guaranteed time on JWST when it is launched in 2018. Membership of ESO would allow it to become involved in constructing cutting-edge instrumentation for the largest telescopes in the world. In turn this will not only provide excellent training opportunities for postgraduate students and postdoctoral fellows but it has the potential, for example, in connection with detector development, of building up long-term collaborations with national institutions such as the Tyndall Institute and CRANN in TCD.

With the termination of the international agreement in 2003, whereby Irish astronomers had access to telescopes on La Palma in the Canary Islands, Ireland now has no formal access to any ground-based astronomical facilities. This situation is unique within the pre-enlargement EU and is a severe blow to the Irish astronomical research community. ESO membership would significantly redress this and enhance opportunities for astronomical research in Ireland. It is also of note that in 2000 the UK International Review Panel for Physical Sciences recommended that the UK should join ESO. This recommendation lead to the UK joining ESO in 2002 and the 2005 report of the International Panel highlights the highly significant benefits to UK astrophysics that have accrued as a result.[8]

Science Foundation Ireland, has in the past, supported the work of astrophysicists. However it is increasingly difficult for Ireland to compete internationally, particularly in relation to achieving European funding in this area. A recent report from the Institute of Physics looked at the scientific performance in physics in Ireland using bibliometrics.[9] The study noted that comparing the period 2002-06 with 2007-11, Ireland's emphasis on physics research decreased and there was a relative decrease in scientific impact of Irish research. Clearly investment in facilities such as ESO would not only increase a focus on physics and physics-related research but also significantly enhance the impact of the publications emanating from academics in Ireland. As a result this would redress the balance and also make Irish astronomers more competitive when seeking European funding grants.

Undergraduate Teaching

Undergraduate degree programmes are available across Ireland and are seen as prime drivers of uptake of science courses in Irish colleges. In IOP Ireland surveys of undergraduate students,[10] 83% of students note that interest in the 'big questions' of the universe was a strong factor in deciding to study physics. Graduates in this area are in high demand and find employment across a range of sectors including imaging and computing. Astronomy provides very good training in the analysis of large, noisy and heterogeneous data sets, with databases typically in the terabyte (1000 gigabytes) range whereas, for instance, the Human Genome Project was working with samples only in the gigabyte level: this is exactly what is required in commercial big data science. Additionally, all astrophysics courses in Ireland have a large physics component meaning that graduates are able to undertake any of the jobs that a 'regular' physicist would fill, with excellent numerical and problem solving transferable skills. As a result, recent graduates have entered positions in fields such as experimental solid state physics, meteorology or 'real-world' jobs such computer software engineering, hospital radiography and the finance industry.

However, success in third level teaching depends upon maintaining and recruiting internationally rated researchers who can bring both knowledge and enthusiasm into their teaching from their own research programmes. These researchers require access to the highest standard of facilities.

Trinity College Dublin Astrophysics Graduates

Astrophysics courses have a high level of computational hours which are aimed at problem solving, rather than computing purely for its own sake. It is of note that students in other courses are requesting a similar level of this type of computation.

Most of these graduates have gone directly into employment, particularly in the software field, where they are in high demand. The development of an active solar and stellar research group at TCD has corresponded with a growth of interest from undergraduates students who are influenced by research-led teaching. More particularly, astrophysics has proved to be attractive to female undergraduates and addresses one of our goals to tackle gender balance issues. In this year's penultimate and final year classes women students make up an average of 45% over the two years – a much higher percentage than for physics generally (typically around 10-15%.

Ireland has already invested significantly in its astrophysics base in Ireland. There is now a large pre-existing cohort of senior staff well placed to take immediate advantage of ESO membership. The best researchers will be attracted to and will remain in Irish academia if they have access to the highest standard of research facilities.

Women make up around 45% of astrophysics courses in TCD compared with only 10-15% in physics generally.

Undergraduate Teaching continued

A breathtaking 3D light show in Linz, Austria gives audiences a virtual tour of the European Extremely Large Telescope (E-ELT), before construction work has even begun in Chile. (Credit: Austrian Space Forum/O. Haider)

Colleges offering astrophysics degree and research opportunities

Cork Institute of Technology | Dublin City University | Dublin Institute for Advanced Studies | Institute of Technology, Tallaght | NUI Galway | NUI Maynooth University College Cork | University College Dublin | Trinity College Dublin

Outreach and Astronomy

In the search for exoplanets, few telescopes have had as much success as ESO's 3.6-metre telescope (left) and the Swiss 1.2-metre Leonhard Euler Telescope (right), located at La Silla Observatory in Chile. (Credit: Iztok Boncina/ESO)

Astronomy is one of the most significant drivers of public interest in science, and serves to attract students to STEM subjects, and also strong cross-generational interest. Irish researchers working in this area have contributed hugely to this through, for example, regular monthly activities at Dunsink Observatory open nights. Since opening in 2007 the Blackrock Castle Observatory in Cork has delivered education programmes formally and informally from preschool level through Discover Primary Science & Maths, to second and third level and to public, academic and industry sectors. In that time the visitors, internships, tech and outreach numbers have grown to over 100,000 per annum.

Outreach and Astronomy continued

Case Study

Cork Institute of Technology – Blackrock Castle Observatory (CIT-BCO)

Photometry advances and a unique observation program for schools

CIT-BCO developed a fast-imaging two-channel photometer through a Research Frontiers grant from Science Foundation Ireland. One of the unique features of the instrument is that it has allowed researchers to improve the quality of photometry by up to 70% compared to standard photometric methods. The group collaborates with researchers in IT Tallaght on a project to develop techniques to identify fields that are optimum for photometry, with the ultimate aim of understanding the photometric limits that can be achieved using ground-based instruments.

In another development, the group has installed a small robotic telescope in California which allows students in Ireland to have live access to the night time sky in California, taking advantage of the 8-hour time difference. The development of associated STEM materials has been supported by SFI. The group is currently in discussions with colleagues in India to install another robotic telescope there. The ultimate aim is to have a global array of small telescopes for use in STEM education, with local curricular experts developing the materials most appropriate to their regional student population.

Besides these regular events, multiple public and high profile events also demonstrate public enthusiasm. In the past year, speakers at events such as Astronomy Ireland's Star-B-Q have been able to reach audiences of 300, and the widespread community and County Council interest in projects which also address environmental issues such as the creation of the Northern Hemisphere's first Dark Sky Reserve in Kerry.

The strong attendance speaks to public interest in, and commitment to, astronomy and the wonder that access to the sky engenders. This is demonstrated at public events such as the European Space Expo, held at TCD in June 2013 which attracted over 30,000 people over the course of six days – a larger attendance at this event than in any of the dozen cities previously visited, including those with much larger populations such as London, Madrid, or Brussels. This event involved talks and, telescope use, and hands-on demonstrations and was a co-operative effort between astrophysicists and space scientists from a number of institutions.

Education and Training

The Very Large Telescope array (VLT) at Cerro Paranal in Chile. It is the world's most advanced optical instrument, consisting of four Unit Telescopes with main mirrors of 8.2 metre diameter and four movable 1.8 metre diameter Auxiliary Telescopes. (Credit: ESO)

Membership of ESO would provide opportunities for world-class postgraduate training. Through its Student, Fellowship and Associate Programmes, ESO has contributed to the training of hundreds of young scientists and engineers over the years who have since returned to their own countries bringing significant value to their national research programmes.

Access to its excellent outreach programmes could be used as a cornerstone in current Irish science outreach activities. Such ESO activities are particularly geared towards secondary schools and include teaching materials, courses for teachers, summer schools and specific educational projects, often in collaboration with partners such as the European Association for Astronomy Education (EAAE), the EIROforum, the European Commission and others.

ESO Membership Fee

Case Study

University College Dublin – Studying the composition of very distant galaxies

An international team of astronomers, including Dr. Sheila McBreen from UCD School of Physics, has used the brief but bright light from a distant gamma-ray burst source to study the composition of very distant galaxies. The new observations, made with the European Southern Observatory's (ESO) Very Large Telescope, have revealed two galaxies in the young Universe that are richer in heavy chemical elements than the Sun and furthermore, that the two galaxies may be in the process of merging. Such merger events in the early Universe will drive the formation of new stars and may also trigger gamma-ray bursts.

Dr. McBreen had been central to this work as Principal Investigator (two ESO proposals) and co-Investigator (17 ESO proposals) when working at the Max Planck in Germany. Observations obtained from these proposals has lead to papers in Nature and Science and to several papers which have been cited more than 100 times. However, returning to Ireland meant that she could no longer lead ESO proposals. Moreover, scientists in Ireland are missing out on involvement in instrument development in ground-based astronomy and related computational efforts making it increasingly difficult to compete internationally in astronomy.

The entrance fee is based on the country's GDP and for Ireland in 2014 this would be approximately €11.2 million, plus a once-off E-ELT contribution of €1.9 million. The subsequent annual contribution would be €1.6 million. It is likely that the terms of an application for Irish membership of ESO would be negotiated with entry costs perhaps being staggered over a period of years.

For member states, ESO will pay for travel to the facilities in Chile. ESO also offers a range of studentship and post-doctoral funding support, which will be augmented by national awards (e.g. IRCSET, SFI).

It is particularly advantageous for Ireland to join now. Ireland's GDP fell significantly during the recession but is set to rise again, which means that the entrance fee is considerably lower now than it would have been prior to 2008. However, this advantage is likely to be lost with any delay in joining. Additionally, contracts for the construction of the E-ELT will be sought over the following year. Hence this is a key time for Ireland to reap the benefits of membership of ESO.

Case Study

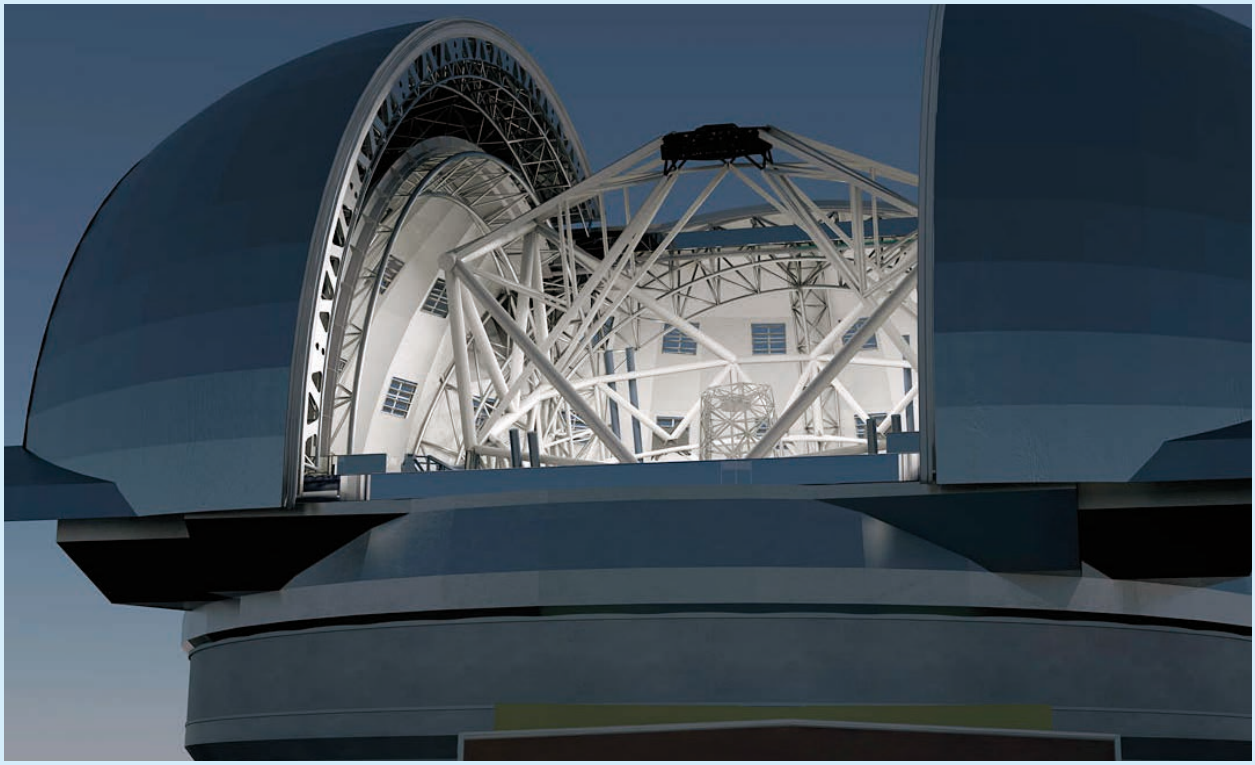
University College Cork – Understanding black holes

One of the core themes of the Relativistic Astrophysics group in UCC (along with studies of jets from AGN and Gamma-ray bursts) is the accurate determination of black hole and neutron star masses.

These measurements are essential to our understanding of how black holes are formed, how we measure their spin, and constraining the equation of state of matter in neutron star interiors. This requires access to the most advanced astronomical facilities, as the observations require high resolution spectroscopy and optical/IR photometry. Such research in Ireland, however, is stymied to a large extent by our lack of formal access to any astronomical facility. Membership of ESO would remedy this, and allow us make significant contributions to this fundamental area of astrophysics. More generally, ESO membership would allow astronomers in Ireland to build on the discoveries that will be made by other large scale facilities in the future – the James Webb Space Telescope, the Square Kilometer Array, the Athena X-ray mission, etc.

A reproduction of a composite colour image of the Horsehead Nebula and its immediate surroundings taken with one of the Unit Telescope of the Very Large Telescope array. (Credit: ESO)

Conclusions



Architectural concept drawing of ESO's planned European Extremely Large Telescope (E-ELT) shows the world's largest planned optical telescope gazing heavenwards. (Credit: Swinburne Astronomy Productions/ESO)

ESO has a coherent, long-term programme, which has provided a remarkable return for astronomy and astrophysics in its member states. This has enabled Europe to regain a leading position in the world with ESO being ranked as the most productive observatory globally. The current and expected future project portfolio is carefully crafted to ensure that the member states will remain at the leading edge. This is particularly relevant when considering Irish prospects for success in attracting European research funding.

In the last round of grants from the European Research Council, proposals in the physical sciences and engineering section attracted the highest percentage of awards – 45% compared with 36% in the life sciences. Ten of these highly prestigious awards were within the astrophysics section[11] with many of the projects using ESO facilities – such as the Gaia-ESO survey which maps more than a thousand million stars throughout our galaxy and beyond. Access to ESO would allow Irish scientists and engineers to compete on an equal playing field in this regard, and hence contributed to obtaining a larger share of EU Horizon 2020 funding.

Membership of ESO would give Irish firms the opportunities to bid for significant R&D contracts. Additionally, there is a very substantial multiplier effect in that by working at and beyond the limits of standard technology, firms gain a competitive edge in the global market place and benefit from inward technology transfer. This would be particularly true for firms in the computing sector, but also for radio communication and advanced optics businesses, all areas where Ireland has growing strengths. Such factors considerably offset the initial entry fee.

For an investment of around €29.1 million over 10 years, Ireland can expect a direct return to industry of around €11.2 million over the same period. Such contracts have a considerable multiplier effect and would be worth around €66 million to the economy using comparable figures from ESA contracts.[6]

Membership of ESO would give significant benefits to Ireland including greater international impact of researchers based in Ireland, a higher skilled STEM graduate workforce and a significant economic boost to the high-tech sector.

The time is long overdue for Ireland to take its place in Europe's foremost astronomical research facility, and to make the most of the preferential rate as out economy recovers, and prior to the major ESO's investments in new facilities and the scientific and technological challenges of the E-ELT.

"An almost unique level of international cooperation is achieved at ESO, and everything is done by those who can do it best, irrespective of their country or institution. This spirit of excellence is an example for all Europe."

Mrs. Maria van der Hoeven, Minister of Education, Culture and Science, the Netherlands

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