antennas on the plateau. However, on my 28th birthday I observed with the James Clerk Maxwell Telescope and finally saw world-famous telescopes like Keck with my own eyes. It was an unforgettable experience. With the Karl G. Jansky Very Large Array (VLA), we studied the properties of dense gas in those lensed starbursts and, little by little, I realised that my passion is for astronomy observations, including the joy when the proposal is accepted, and the excitement of checking freshly acquired data.

During the last year of my PhD, when I received an offer from ESO for a fellowship in Chile in January 2017, I was thrilled that I would be working with ALMA, the most powerful (sub)millimetre telescope that I dreamt about back in 2010. My dream came true and I moved to Chile in November 2017.

At ESO, I spend 50% of my time at ALMA performing functional duties. I still remember my first trip to the 5000-metre-high array operations site of ALMA. The landscape is simply Martian. I have enjoyed participating in the science operations at ALMA a lot, where I keep learning every day and work to contribute to ALMA. During the other half of my time, I continue my research into molecular gas and dust in galaxies. Using ALMA, I acquired images of dust and gas emission at scales of 100 pc for dusty galaxies when the Universe was about two billion years old. I am also using the NOrthern Extended Millimeter Array (NOEMA) of IRAM and ALMA conducting spectral line surveys of high-redshift galaxies, pushing the limit of astrochemistry studies to the early Universe. Besides, the submillimetre H_2O emission from galaxies has been one of my areas of interest. With the Atacama Pathfinder Experiment telescope (APEX), we achieved the first detection of the 752-GHz H_2O line in extragalactic systems from the ground.

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External Fellows at ESO

In addition to the ESO fellowships, a number of external fellows are hosted at ESO. Profiles of two of these fellows are presented here.

Prashin Jethwa

It could so easily not have happened at all! My two-year stint at ESO has been a fortunate coincidence. Sidestepping the usual route taken by fellows, my voyage through the seas of ESO has been at the command of a brave captain: Glenn van de Ven. I joined Glenn's group, funded through a European Research Council grant, for a position which was originally intended to be hosted at the Max Planck Institute for Astronomy in Heidelberg. However, along with Glenn, my position moved to ESO Garching, where I have been based since October 2017. No sooner have I learnt to navigate through the ESO headquarter buildings, however, than my time here has come to an end. I will soon move to re-join the newly appointed Professor van de Ven, this time at the Institute for Astrophysics in Vienna. Despite, then, my time at ESO having been largely unplanned, it has been an immense pleasure, and I leave as a more enriched and fulfilled person than when I arrived.

I was born and raised in London, where I spent my childhood enjoying football (Liverpool), Pokémon (Charizard), and ice cream (all varieties). Notably absent from this list is astronomy. Perhaps I can blame urban light pollution, but I cannot claim to have been especially awestruck by the Universe in my formative years. Rather than looking up through a telescope, I kept my head down, often in a mathematics textbook. This is what really absorbed the academic side of my youthful brain: maths problems, puzzles and... polynomials? This led me to the University of Cambridge, where I completed an undergraduate degree in mathematics. It was a broad curriculum, spanning aspects of pure and applied maths as well as theoretical physics. The latter topic dominated my choice of courses in the final year, reflecting my evolving interest in mathematics: not just as an abstract puzzle, but a tool for modelling real phenomena and solving real problems.

My transition then began in earnest. I chose to continue at Cambridge with a master's degree in astronomy, learning the fundamentals of the subject from a mostly theoretical perspective. I then spent a year as a European Space Agency (ESA) Young Graduate Trainee in Madrid, where I got to experience a more "hands-on" side to astronomy. My project at ESA consisted of modelling overexposures on the cameras of XMM-Newton, a space-based X-ray telescope. During this time, I also enjoyed my first look through a telescope. After an impromptu 100-kilometre drive south of Madrid with a friend's 20-inch Dobsonian telescope, I saw Saturn's rings, Jupiter's moons and made amends for my youthful oversight. Having ticked this box, gained some substantial research experience, and seen part of the wider astronomy community, I felt ready to move on to the next step.

For my doctoral studies, I returned to the Institute of Astronomy in Cambridge. Under the supervision of Vasily Belokurov and Denis Erkal, I completed a thesis about the Milky Way halo. The halo refers to the region out to distances of a few

hundred kiloparsecs from the Galaxy. It is filled with satellite galaxies, star clusters, and diffuse clouds and streams of stars, all orbiting around the Milky Way. Structures in the halo are remnants of smaller galaxies merging with the Milky Way over timescales of billions of years. By disentangling and characterising these structures we can see into the Galaxy's past evolution and growth.

One main result from my thesis concerns newly discovered dwarf galaxies. Early in my PhD, two teams raced to report the discovery of dozens of dwarf galaxies in the Dark Energy Survey (DES), a photometric survey in the southern hemisphere. The number of dwarfs discovered in DES far exceeded expectations from previous, similar surveys in the north. One possible explanation for this overabundance was that the new dwarfs were associated with the Magellanic Clouds, the largest of the Milky Way satellites, which lay close the boundary of the DES footprint. I tested this hypothesis by building a dynamical model of the Magellanic Clouds, Milky Way and dwarf galaxies, and devising a statistical framework to compare this model to observations. The results confirmed that most of the DES dwarfs were likely to be associated to the Clouds, and furthermore predicted their velocities, several of which have since been corroborated with follow up observations. This work encapsulates the main tools used in my research, which are mainly theoretical, with plenty of dynamics, and using statistical modelling techniques.

Moving to ESO, my scientific focus has shifted slightly. Whilst still interested in the evolution and growth of galaxies, I now focus on those outside of our local neighborhood. The type of data available for studying more distant galaxies is very different from data we have in the Milky Way. Some of the richest datasets come from Integral Field Units (IFUs). These observe not just 1D spectra, or 2D images, but 3D data-cubes: images where every pixel of the image contains a spectrum. A powerful method to study galaxies using IFUs is decomposition, i.e., breaking the data-cube down into parts that represent physical components. This can reveal the history of when stars were formed, how the chemistry of gas and stars evolves, and uncover the remnants

Prashin Jethwa

of past galactic mergers. Decomposition is therefore very powerful, but it can be computationally challenging and will become increasingly challenging as data quality improves. Some of the highest quality IFU data currently come from the MUSE instrument on the VLT and, looking to the future, the High Angular Resolution Monolithic Optical and Near-infrared Integral-field spectrograph (HARMONI) on the Extremely Large Telescope (ELT) will improve spectra and spatial resolution yet again by orders of magnitude. To prepare for this increase in the size and quality of data, I have been investigating dimensionality-reduction techniques to allow us to perform decomposition for large datasets. Alongside many other examples, this project has expanded my scientific horizons.

In addition to being scientifically eye-opening, in my two years at ESO I have grown in several other ways. The students and fellows I have met in Garching are an exceptionally proactive and engaged group of people. We take excellent advantage of opportunities provided to us and take the initiative to create further opportunities for ourselves and future ESO scientists. Seizing these opportunities has been a key part in my personal development. I leave with teaching experience, having co-supervised an undergraduate summer student in the inaugural ESO Summer Research Programme, and PhD student Meghan Hughes who is enrolled in the ESO studentship programme. I leave with enhanced organised skills, having organised the ESO Garching Science Day, group meetings and one of several seminar series. I leave with an unexpected friendship with the owner of the local *Getränkemarkt* (bottle shop) having bought hundreds of crates for our weekly after-work Beer Fridays. On display here, every Friday, is the warm atmosphere and friendly, interesting people who really make ESO a pleasure to be part of. Above all, I leave ESO with countless good memories and friends.

Foteini Oikonomou

I was born and grew up in Athens, Greece. I cannot remember a fascination with the night sky, perhaps because of the light-pollution in Athens, until at an age of around nine I visited the observatory of Penteli during one of the open evenings. That evening we observed the Hercules globular cluster. Hearing the astronomers there describe the system we were looking at and explain the time it had taken the light to reach us made me, for the first time, very aware of the vastness of the Universe and filled me with a sense of wonder.

During my teenage years, my interest in the Universe grew, mostly from reading popular science books and occasional visits to the observatory. Those were the days without internet, and I can remember that I got into the habit of scanning the local press for information about the next open evening at the observatory, and the frustration I felt when I couldn't find anything scheduled. In high school, I decided to take mostly science courses so that I could apply for a university degree in astrophysics. I chose my high

school diploma thesis to be on black holes because they captured my curiosity the most. I think that Stephen Hawking's popular science books were what sparked this interest. I have since confirmed that this was the case for many of the fellow astrophysics students of my generation at university.

I went to England to study astrophysics at University College London (UCL). I made the decision because there was no bachelor's degree in astrophysics in Greece. It seemed to me at the time that studying physics instead wouldn't be as much fun. It was in London that I truly got acquainted with astronomy. The degree I took involved many astrophysics courses, but also lots of time using telescopes and analysing astronomical data at the University of London Observatory. I am still fascinated by the dedication and excitement of all the astronomers there, for the great research they manage to do, just next to the A1 motorway in the suburbs of the often cloudy London!

In my final years at university, I became most interested in extragalactic astrophysics and elementary particle physics. I decided that I'd like to pursue a PhD on a topic which combined elements of both. At the time, UCL launched an initiative called the Institute of Origins, designed to foster collaboration between the Particle Physics and Astrophysics groups at UCL. In this platform, I found a PhD topic that greatly interested me: an investigation on the origin of ultra-high-energy cosmic rays. These fascinating messengers of the extreme Universe, which are most likely extragalactic, are the most energetic particles known. They possess energies ten million times higher than the particles that can be accelerated at the Large Hadron Collider. We do not know by what astrophysical objects they are accelerated, and to this day, this question has been the backbone of my research endeavours.

I was fortunate enough to be offered a PhD position at UCL. I still remember the offer email I received as one of the happiest moments of my life. I worked alongside Ofer Lahav, Amy Connolly, and Kumiko Kotera on the signatures of plausible astrophysical sources of ultra-high-energy cosmic rays. Towards the end of my PhD, I was offered a postdoctoral position at the Pennsylvania State University (Penn State). There, I was able to work alongside Miguel Mostafa and Stephane Coutu on the Pierre Auger Observatory. This is the largest ultra-high-energy cosmic ray detector ever built. Distributed particle counters cover an area of 3000 square kilometres in the pampa, in the Mendoza region of Argentina. I was lucky to be able to visit the experiment several times and to operate the fluorescence telescopes during shifts. During my time at Penn State, I also worked alongside Kohta Murase on jetted active galaxies, called blazars. These objects are powered by the Universe's most massive black holes and have long been thought to be sources of ultra-high-energy cosmic rays.

I next moved to ESO, to my current position, to work alongside Paolo Padovani and Elisa Resconi on blazars, and on high-energy neutrinos, expanding my multi-messenger expertise so as to tackle the ultra-high-energy cosmic ray problem from additional directions. The time of my arrival in Munich was very opportune because, within a week of the start of my position at ESO, the IceCube neutrino detector registered an alert for a high-energy neutrino coincident with a flare from the powerful blazar, TXS 0506+056. This event probed in-depth investigations on neutrino emission from this and other blazars, and I was very lucky to be able to research this topic in the midst of world experts on blazars and on high-energy neutrinos.

At ESO and the surrounding institutes in Garching, the opportunities to grow as a scientist seem endless. I heard somewhere that Munich is the city with the largest number of astrophysicists in the world. I do not know if this is true, but it certainly feels that way. At ESO and in Garching I enjoy the very rich variety of excellent weekly talks, and other regular events, the Joint Astronomy Colloquium, Active Galactic Nuclei (AGN) Club, Journal Club, and the various weekly seminars of the many institutes in Garching. My position is funded by the DFG (German Research Foundation) collaborative research centre SFB1258: Neutrinos and Dark Matter in Astro- and Particle Physics. Within this programme, I am able to participate in additional regular cross-institute colloquia, lectures, and workshops, collaborative gatherings with artists, and outreach activities. While writing these lines I realised that not much has changed in my main astrophysics interests since as a teenager I got excited by the mysteries of the high-energy Universe, and the mysteries of black holes. I feel very fortunate to be able to nourish this curiosity every day.

Foteini Oikonomou