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External Fellows at ESO

In addition to the ESO fellowships, a number of external fellows are hosted at ESO. A profile of one of these fellows is presented here.

Zhi-Yu Zhang

I still feel moved when I recall the moment that I happened to watch the Geminid meteor shower, on one freezing winter night in 2009, during a gap in my observations at Mount Graham in the USA. It was my first year as a PhD student when I started to learn about the Universe as much as possible. Actually, this observing trip was associated with my first successful observing proposal, which was to use the 10-metre Heinrich Hertz Submillimeter Telescope to observe dense molecular gas in external galaxies. That day was also my birthday, full of surprises and fun — just like my research career.

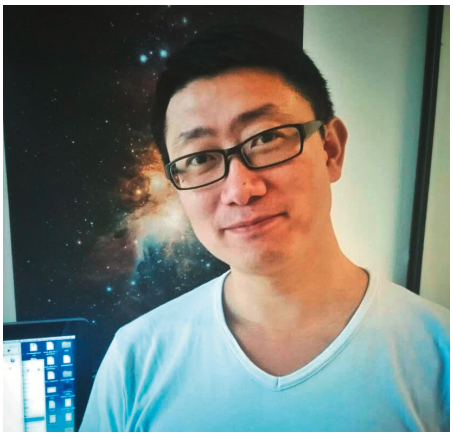
I was born in the mountainous southwest region of China, in the Guizhou Province, which is now well known for hosting the Five-hundred-meter Aperture Spherical radio Telescope, FAST. When I was four years old, my family moved to the eastern part of China, the Anhui province, where I spent a large portion of my childhood reading. The book series titled *"One hundred thousand Why"* enlightened me in the exploration and understanding of the principles that the world follows. Therefore, I selected particle physics for my major in my bachelor degree, at the University of Science and Technology of China (USTC) — with ambitions to understand the ultimate rules of the Universe. I was involved in research into quantum information and quantum computers, which have the potential to provide revolutionary technology for human beings.

However, after a two-year struggle with trying to understand quantum physics, I realised that it takes talent to make a real breakthrough in fundamental physics. Keeping an enthusiasm for physics, I made a life-changing decision and switched to astrophysics. Yu Gao kindly accepted me as a masters student at the Purple Mountain Observatory (PMO), at which point I started my astronomical life.

My first project was to study the line emission of carbon monoxide towards a Galactic supernova remnant, IC 443, which is interacting with ambient molecular clouds. The energetic blast wave from the massive star exploded a few thousand years ago, brutally tearing up the interstellar medium (ISM), dissociating molecules, ionising atoms, and returning newly processed elements to the gas. It is only a tiny part of the baryon cycle in the evolutionary history of our host galaxy, the Milky Way. Actually, I did not know much about what I was doing until I arrived at the PMO 14-metre telescope in Delingha on the 3200-metre high Qinghai-Tibet plateau. My first observations blew my mind. Operating a large telescope, pointing it to science targets, collecting photons, and being the first to see a small "secret" of the Universe, is a non-stop exciting feeling.

Which gases form stars? This is the key question that my PhD project addressed. Only when the molecular gas is dense enough can the gas collapse by gravity and initiate the formation of stars. But what is the density range, and what kind of initial physical conditions matter for the molecular gas? To answer these questions, I went to the Max Planck Institute for Radio astronomy (MPIfR) in Bonn, Germany, as a visiting student working with Christian Henkel and Karl Menten for two years. At the MPIfR, I had opportunities to observe with the Atacama Pathfinder EXperiment (APEX 12-metre) telescope several times; this is my favourite single-dish sub-millimetre facility — both for its world-leading performance and for the family feel. Onsite observing at the 5000-metre high Atacama plateau, where it is extremely dry and lacks oxygen, has been my most exciting adventure.

After my PhD, I moved to Edinburgh to continue research as a postdoc, working closely with Rob Ivison. There, I started to work on galaxies in the early Universe, especially on their ISM properties, including ionised gas, molecular gas and dust. We realised that the afterglow of the Big Bang, the so-called cosmic microwave background (CMB), can seriously frustrate our efforts to image the cold hydrogen gas molecules and cosmic dust found in galaxies in the distant Universe. As the CMB background becomes



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warmer and warmer in the distant Universe, its temperature becomes almost equal to that of the cold, optically-dark ISM in galaxies. This effect makes that ISM nearly invisible against the rising glow of a warmer CMB, and thus it becomes very hard to detect molecular gas where new stars will form in distant galaxies. It would be like trying to see a swan in the snow, or the shrinking of an ocean island in a rising tide.

After I moved to ESO Garching as an external fellow, my science interests extended to elementary abundances in galaxies and their evolution across cosmic time, especially the isotopes of CNO elements, which in principle could be measured in the ISM. We selected C^{13} and O^{18} isotopes as the target because C^{13} is mostly synthesised by low- and intermediate-mass stars, while the O^{18} production is dominated by massive stars. We performed simultaneous observations of ^{13}CO and $C^{18}O$ emission lines using the Atacama Large Millimeter/submillimeter Array (ALMA), towards a sample of dusty starburst galaxies at $z \sim 2$–3, less than 3 Gyr after the Big Bang. Our new measurements, combined with $^{13}CO/C^{18}O$ ratios found in other types of galaxies, show a systematically decreasing trend from galaxies with low-level star-formation to dusty starburst galaxies — indicating that more massive stars are needed to supply the O^{18} overabundance in starburst galaxies.

Working at ESO Garching is a unique experience for me. There are so many ongoing interesting scientific activities

every week, for example: Gas Matters, Informal Discussions, Knowledge Exchange Series, Wine & Cheese, AGN Club, Journal Club, etc., not to mention the other regular seminars and workshops on the campus. I appreciate the chance to see so many different fields converge and overlap, and to learn something new every day. At ESO, all fellows are fully independent and great minds do meet together, as a result of which I enjoy collaborating with ESO fellows and staff. I learned from the ESO community that, no matter how crazy your idea is, give it a good try and you will always be pleasantly surprised by new discoveries, new physics, and challenges to classical knowledge with critical thinking.

Acknowledgements

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Personnel Movements

Arrivals (1 January–31 March 2019)

Europe

Caillier, Patrick (FR)	Project Manager
Fiorellino, Eleonora (IT)	Student
Wassill, Sebastian, (DE)	Logistics Officer

Chile

Azcarate, Camilo (CO)	Ombuds
Blanco Lopez, Leonardo (FR)	Instrumentation Engineer
Moulane, Youssef (MA)	Student
van Holstein, Rob (NL)	Student
Vasquez, Paulina (CL)	Safety Engineer

Departures (1 January–31 March 2019)

Europe

Aros Pinochet, Francisco Ignacio (CL)	Student
Brucalassi, Anna (IT)	Astronomer
De Cia, Annalisa (IT)	Fellow
Escate Giribaldi, Riano (PE)	Student
Flörs, Andreas (DE)	Student
Guha, Rebonto (DE)	Senior Clerk
Jethwa, Prashin (UK)	Fellow
Kravchenko, Kateryna (UA)	Student
Lucchesi, Romain (FR)	Student
Patig, Markus (DE)	Deputy Director for Science
Prole, Daniel (UK)	Student
van de Ven, Glenn (NL)	Astronomer
Watkins, Laura (UK)	Fellow

Chile

Aguilar, Max (CL)	Hospitality Operations Supervisor
Carcamo, Carolina (CL)	Procurement Officer
Gonzalez, Leonardo (CL)	Mechanical Technician
Mejia-Restrepo, Julian (CO)	Fellow
Sánchez Sáez, Paula (CL)	Student
Santamaría Miranda, Alejandro (ES)	Student