IET International Travel Award 2022 - Travel Report

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Understanding the formation of the stars in our Galaxy, in particular of the most massive ones (i.e. with masses above 8 solar masses), is a crucial step towards understanding the composition of the Milky Way. Nevertheless, this mechanism is still far to be understood, mostly because massive objects are relatively rare and short-lived, compared with the less massive stars.

In the last years, thanks to the availability of new and advanced facilities, like Atacama Large Millimetre/submillimetre Array (ALMA) observatory, many birth site of these massive stars, the so-called clumps (objects with radius of ~1 parsec or 30.9 trillion kilometres), have been observed with unprecedented resolution and sensitivity. These advanced data appear to be a unique source of information for understanding the formation of the stars.

Thanks to IET Travel Award 2022, I was able to carry out a 3-month research experience in the Institute for Space Astrophysics and Planetology (IAPS), located within the National Council of Research (CNR) in Rome, Italy. The aim of the research was the development of an algorithm for the analysis of high resolution images of specific star-forming regions in our Milky Way. The images I used were acquired from the most advanced interferometer to date, ALMA, under the project 2018.1.00443.S, Star formation in QUiescent And Luminous Objects (SQUALO) (squalo.pbworks.com/). The goal of SQUALO project is to shed light on the dynamics of the formation from the clump scales down to the protostellar cores (<0.1 pc), with a particular focus on the interplay between the two main actors that contribute to the formation of the final massive stars: turbulence and gravity. One way to look at this interplay is by analysing the dynamics of the gas in these regions as traced by optically thin and optically thick molecules, such as HCO+(1-0) and the $H^{13}CO+$(1-0).

My research experience, under the supervision of Dr. Alessio Traficante, was dedicated to the analysis of the emission spectra of these lines in SQUALO sample. To perform the analysis, I developed a software in Python capable of analysing high spectral resolution data to the end of identifying spectral line emission and fit the lines profiles of the HCO+(1-0) and the $H^{13}CO+$(1-0) molecules.

Although my university studies gave me many opportunities to gain experience in software development, I had never developed code in Python intended to analyse radio interferometric data. This posed a challenge for me, but also a unique opportunity to improve my skills and knowledge. The transferable skills acquired during my years at UCLAN and the support of IET travel Awards have been invaluable for my educational and career goals.

The data from the SQUALO project are saved in Flexible Image Transport System (FITS) format, which is a format commonly used in astrophysics. FITS files consist of multi-dimensional arrays, in this case 3-D datacubes (see Figure 1), and they need to be manipulated to extract useful information from which significant images can be constructed. Firstly, I learnt how to manipulate the FITS file in Python. Then, I developed the algorithm in Python to compress on the zeta axis the 3-D datacubes (see Figure 2), through the moment maps (0^{th} and 1^{th} moment), applying specific masks on different regions (See

Figure 3). This allows the analysis of the spectrum using a Gaussian distribution and the determination of the outflows from the core of the clump (see figure 4). From this information, details on the clumps formation can be evaluated.

The IET Travel Awards allowed me to spend 3 exciting months in the CNR. Working on site meant that I could carry out my research on the SQUALO project while also engaging with other researchers, institutes and facilities in Italy. The visit at the Institute for Microwaves and Microelectronics of the CNR (IMM-CNR) was particularly stimulating and I am grateful to Dr Emanuela Proietti for showing me IMM facilities and kindly introducing me to some of their fascinating projects. Seeing their clean room and learning about processes used to develop microwave systems and electronic components inspired my Bachelor Project. IET Travel Awards gave me priceless opportunities for learning and for collaborations with international professionals as Dr Proietti is currently supporting me in my project.

I would like to take this opportunity to express my sincere gratitude to the IET for this prestigious award, which allowed me to spend 3 months in Rome, complete the research project and live an experience that has boost my knowledge, confidence, networking skills and CV. I wish to extend my gratitude to my UCLAN tutor Dr Mara Bernabei for her assistance and contribution throughout this project but also for her support in every part of my studies, her knowledge and experience have played a significant role in shaping my academic progress.

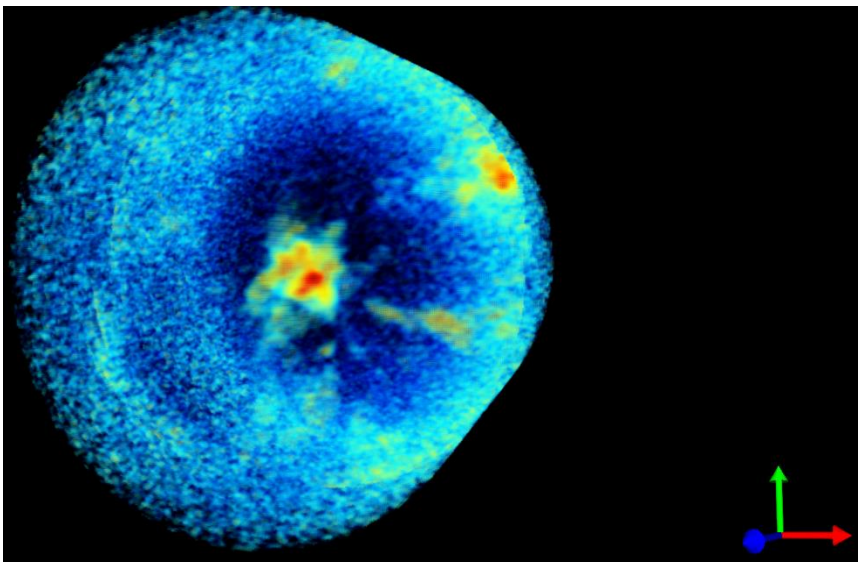

Figure 1 Reduced data cube

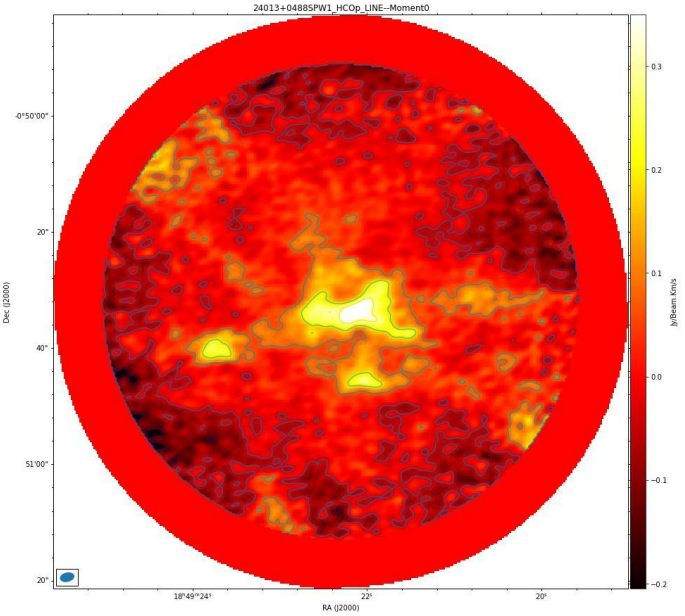

Figure 2 Moment 0 map

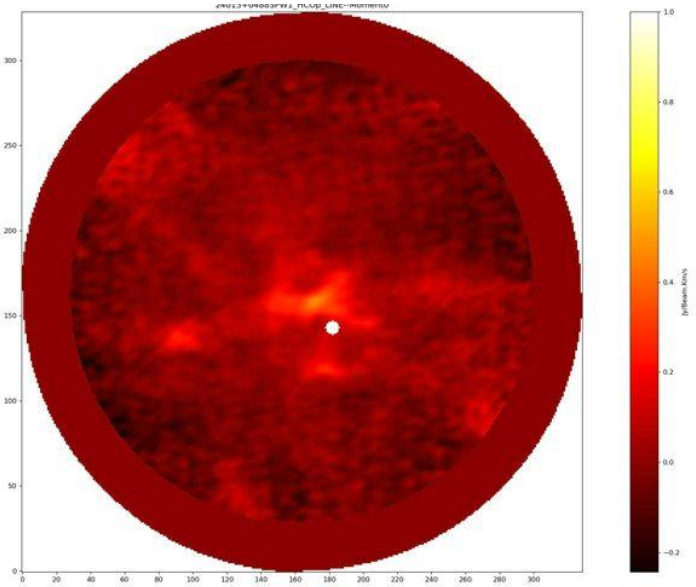

Figure 3 Selected mask on moment 0

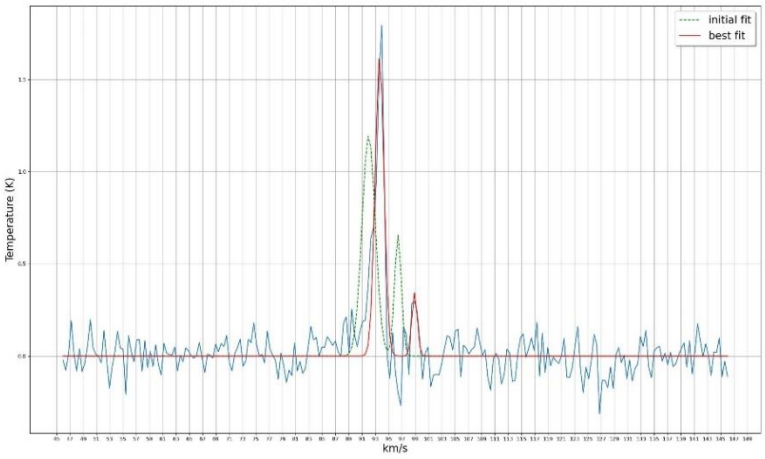

Figure 4 Spectrum analysis for the individual mask

Travel Award Winner 2022