



Charlemont grant report

Recipient name:	Dr Donna Rodgers-Lee
Discipline and subject area:	Sciences
Amount and year awarded:	€1,736 in 2022
Title of project:	Modelling the impact of high-energy particles on chemistry in exoplanet atmospheres.

Summary of findings:

The aim of the travel grant was to combine models of energetic particle transport through a stellar system and in an exoplanet atmosphere and finally to input these results into a chemical model of exoplanet atmospheres. The travel grant consisted of two one-week trips to the University of Cambridge to collaborate with Dr Paul Rimmer. The research aim was to constrain the chemical impact of energetic particles in exoplanet atmospheres. We successfully combined these models and were able to run chemical models of the exoplanet atmospheres. There was a really good exchange of knowledge relating to our different models and exoplanet atmospheres in general.

One of the key achievements of our collaboration is that we found from our models that the level of ionisation due to energetic particles in the atmospheres of exoplanets orbiting close to their host red dwarf stars can be considerable which could have a significant effect on the chemistry in these atmospheres. We were interested in gas giant exoplanets, like Neptune or Jupiter because these atmospheres will be more easily observed with the James Webb Space Telescope and ESA's upcoming mission, Ariel, dedicated to characterising exoplanet atmospheres. Much higher pressures are reached in gas giant atmospheres than on Earth. However, it has been suggested that life began on Earth shortly after a large impact which would have increased the pressure of Earth's atmosphere by up to a factor of a hundred at the surface. This means that our models of gas giant atmospheres are in some sense comparable to a post-impact early Earth atmosphere. At these high pressures we found that Galactic cosmic rays from outside the Galaxy were more important as an ionising source than stellar energetic particles coming from the host star itself. This suggests that perhaps Galactic cosmic rays were the dominant source of ionisation on the surface of the early Earth. This result is very interesting and may help inform our understanding of how life began on Earth.



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Plans for continuing collaboration:

Paul Rimmer and I are planning, along with a number of other researchers, to complete the chemical modelling of exoplanet atmospheres including the results from our work together on energetic particles. This is broadly linked to our membership in the Ariel consortium.

We also plan to investigate further the impact of energetic particles in an atmosphere representative of Earth's atmosphere after a massive impact which is around the time life is thought to have begun on Earth. This will be a continuation of our collaboration together. I hope to visit Cambridge again in the next year or two, along with my PhD student.

Published work and publication plans:

We will submit the first of two publications shortly, focusing on the physical models. The second publication on the chemical effect of the energetic particles in exoplanet atmospheres will be submitted next year. We decided to separate our project into two publications because there were a lot of interesting results.

Dissemination and plans for future dissemination:

During my first research trip, I gave a talk about my research as part of the Leverhulme Centre for Life in the Universe coffee mornings. In terms of conference talks, I have given/will give five talks relating to research results from this collaboration thus far:

1. Invited review talk at the Chianti workshop on exoplanet atmospheres in April, Italy.
2. Contributed talk at the General Ariel Consortium meeting, Paris.
3. Contributed plenary talk at the bi-annual Cool Stars 2022 conference, July, Toulouse (600 in-person participants). This is the most important conference in the field of low-mass stars.



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4. Contributed talk at the Irish National Astronomy Meeting, September, Dublin.
5. Invited talk at the 779th WE-Heraeus seminar 'From the heliosphere to astrospheres – lessons for exoplanets and their habitability', January 2023, Germany.

Additionally, I organised a conference session for the Europlanet Science Congress (1200 participants), Granada which was related to the research I conducted as part of the Charlemont grant.

Collaborations and planned collaborations:

I have joined additional discussions within the chemical working group in the Ariel consortium with international academic partners in France and the Netherlands focusing on stellar flares, for instance. The aim of these discussions is to lead to new projects on these topics.

Outreach and engagement activities:

Public engagement is a really important component of research. I have participated in a number of outreach activities relating to my research this year.

I gave a short talk about my research for a special interest group earlier this year at Dunsink Observatory which is managed by the Dublin Institute for Advanced Studies.

I was also delighted to give a talk entitled 'Slimer or X-Men Mutants: How energetic particles can affect life on other worlds' at DIAS' Samhain agus Science festival at the beginning of November. The talk was recorded and can be viewed here: <https://youtu.be/2g8dhpFz79o>. I will be interviewed by Aaron Downey about my research on Dublin Digital Radio on 9th December 2022 from 3-5pm. This is part of a radio show called Free Trance FM and will be available online afterwards as well: <https://listen.dublindigitalradio.com/home>

I am also planning to contribute to an article in the near future for the Ariel consortium.