**University of Leicester Future 100 PhD Scholarship**

**Project Reference: RI-SPACE-Williams**

**Section 1 – *Supervisor Information***

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| **First Supervisor** | Dr Hugo Williams |
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| **Proposed Second Supervisor** | Dr Beatriz Sánchez-Cano |

**Section 2 – *Project Information***

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| **Project Title** | IntegNuRet – **Int**egrating Novel Space **Nu**clear systems and science **Ret**urn for novel space missions. | |
| **Project Highlights:** | 1. | Identify novel adaptation or development of current state-of-the-art space nuclear power technologies. |
| 2. | Use a truly interdisciplinary approach to develop and quantify the development of these technologies in parallel with the science return and mission concepts. |
| 3. | Use facilities and research environment of Space Park Leicester Institute of Research and Innovation, the two Schools and established and supportive team to produce high-impact outputs. |
| **Project Overview** | | |
| The University of Leicester has a world-leading role in developing americium-241 power systems for future spacecraft, and using this expertise to contribute to growing UK-led efforts to develop space reactors. This technology is enabling to exciting planetary and space science. Without space nuclear power, transformative space missions like the Voyagers, Cassini, New Horizons, Curiosity and Perseverance would not have been possible.  A challenge of great significance in this field is a “chicken-and-egg” paradox between space exploration mission studies and the formal requirements needed to develop these technologies: mission studies need to select technologies that have been developed to a credible maturity, but to do so needs well defined requirements from those missions. Leicester has led development of mature designs of Radioisotope Heater Unit (RHU) and Radioisotope Thermoelectric Generators (RTG) for Europe. With these programmes now focussed on development to flight readiness, an exciting research question is what planetary and space science could be enabled by novel adaptations or developments of these designs. These cannot be explored within the constraints of these main programmes.  The originality of this PhD is to tackle the technology and mission concepts in a fully integrated manner to quantify the link between technology and science return more directly than has been previously attempted. Specifically, the research will identify and develop novel variations such as small-scale RTGs or nuclear-electric hybrids and develop these in parallel with topical space research questions and missions to the lunar and Martian surface, and outer solar system.  This is expected to generate high impact journal and conference publications. The originality of linking the enab*ling* technology and enab*led* science so closely enhances the likelihood of adoption and therefore contribution to successful REF impact case studies.  This project will represent an extraordinary opportunity for a postgraduate researcher to work on a truly interdisciplinary project at the interface of Engineering and Physics, on a project combining theoretical and practical aspects and in a supportive research environment of established researchers and world-class facilities. It is expected to attract a very high calibre of applicant and give them a foundation for a successful academic or industrial career. | | |
| **Methodology** | | |
| The project literature review will be conducted with the dual aim of review and down-selection of a number of novel variations on existing space nuclear system designs, and identifying planetary and space science research questions and related missions. The output of the literature review will be a number of case studies to pursue, along with a decision on the level of detail to be pursued on each case study.  The bulk of the analytical research will consist of design, simulation of system performance and missions, using the combined experience of the Space Park Leicester Institute of Research and Innovation, and the two Schools in industry-standard tools such as Siemens NX, COMSOL, GMAT, and Concurrent Design Facility (CDF) based approaches, plus specialised methods and modelling approaches applicable to relevant space science and instruments. Practical work will focus on development of Laboratory Breadboards to substantiate performance.  **References**  Sánchez-Cano B, Lester M. et al. 2021. Mars’ plasma system. Scientific potential of coordinated multipoint missions: “The next generation”. *Experimental Astronomy*. <https://doi.org/10.1007/s10686-021-09790-0>  Ambrosi RM, Williams HR *et al*. 2019. European Radioisotope Thermoelectric Generators (RTGs) and Radioisotope Heater Units (RHUs) for Space Science and Exploration. *Space Science Reviews* **215**, 55. <https://doi.org/10.1007/s11214-019-0623-9>  Mesalam R, Williams HR *et al*. 2018. Towards a Comprehensive Model for Characterising and Assessing Thermoelectric Modules by Impedance Spectroscopy. *Applied Energy* **226**. 1208-1218. <https://doi.org/10.1016/j.apenergy.2018.05.041>  Witasse O, Sánchez-Cano B *et al*. 2017. Interplanetary coronal mass ejection observed at STEREO-A, Mars, comet 67P/Churyumov-Gerasimenko, Saturn, and New Horizons en route to Pluto: Comparison of its Forbush decreases at 1.4, 3.1, and 9.9 AU. *Journal of Geophysical Research: Space Physics* **122**, 7865– 7890. <https://doi:10.1002/2017JA023884>  Williams HR, Ambrosi RM *et al*. 2012. A conceptual spacecraft Radioisotope Thermoelectric and Heating Unit (RTHU). *International Journal of Energy Research* **36**: 1192-1200. <https://doi.org/10.1002/er.1864>  Williams HR, Ambrosi RM & Bannister NP. 2011. A Mars hopping vehicle propelled by a radioisotope thermal rocket: thermofluid design and materials selection. *Proceedings of the Royal Society A* **467**. 1290–1309  <http://doi.org/10.1098/rspa.2010.0438> | | |