**University of Leicester**

**Future 50 PhD Scholarship**

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| **Project Reference** | SPACE Mesalam |

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| **First Supervisor** | Dr Ramy Mesalam |
| **School/Department** | Engineering |
| **Email** | [ramy.mesalam@leicester.ac.uk](mailto:ramy.mesalam@leicester.ac.uk) |

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| **Second Supervisor** | Dr Agostino Maurotto |
| **School/Department** | Engineering |
| **Email** | [am1419@le.ac.uk](mailto:am1419@le.ac.uk) |

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| **Additional Supervisor** | Prof. Nigel Bannister |
| **School/Department** | Physics & Astronomy |
| **Email** | [nigel.bannister@leicester.ac.uk](mailto:nigel.bannister@leicester.ac.uk) |

**Section 2 – *Project Information***

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| **Project Title** | Low-power in-core thermoelectric space reactor design concepts for deep space exploration. | |
| **Project Highlights:** | 1. | Originality:  Develop a unique novel low-power space reactor design concept for deep space exploration using advanced thermoelectric technology. A unique systems design code will be developed to model advanced in-core thermoelectric energy conversion based nuclear reactor systems for space applications. Practical experiments will be targeted on state-of-the-art thermoelectric materials and technology. |
| 2. | Significance:  The project aligns with an international drive to develop a range of novel power generation solutions for space and terrestrial applications. The rapid development of space technologies in support of scientific missions will require novel power solutions that extend to kW power levels. These small reactors will be transformative for space missions and zero-carbon terrestrial applications. |
| 3. | Impact:  Academic - This project neatly complements the research priorities of the University of Leicester’s Research strategy by facilitating interdisciplinary research bridging engineering, materials science, chemistry, physics and space science. The project will be undertaken in collaboration with Space Park Leicester and the Leicester Institute for Advanced Studies; the outcomes are also relevant to University’s Centre for European Law and Internationalisation (CELI).  The findings of the project will likely make an impact on the regulation of space power sources within multilateral fora, e.g. the UN Committee on the Peaceful Uses of Outer Space (COPUOS). |
| **Project Summary** | | |
| Nuclear technology has long played a vital role in prominent space missions. The University of Leicester is a global leader in the development of space nuclear power systems for electrical power generation, spacecraft heating and thermal management, as part of a European Space Agency funded programme.  The use of nuclear reactors to provide significant amounts of electrical and thermal power for use in space has been well documented. Low power (1 – 10 kWe), in-core energy conversion reactor concepts have been shown to have certain advantages over other designs Including a reduction of mass, size, and thermal-hydraulic complexity, while also minimising thermal losses and increasing energy conversion efficiency. Historically, in-core energy conversion reactor concepts have primarily focused on the use of vapour-filled thermionic conversion technologies. However, recent advances in new nano-structuring approaches have realised a range of new thermoelectric alloys with relatively high thermoelectric efficiency over a wide temperature range, making them an ever more attractive option for in-core energy conversion reactor concepts. Solid-state thermoelectric energy conversion also offers the practical advantage of not requiring an alkali vapour supply system, as is the case for vapour-filled thermionic converters, further reducing overall system complexity.  The project will focus on developing novel low-power space reactor design concepts for deep space exploration using advanced thermoelectric materials and technologies currently under development at the university of Leicester. Using multi-physics models, overall system design codes will be established to evaluate and trade-off design concepts. With the support of industrial partners, candidate thermoelectric materials will be fabricated and experimentally tested to assess the feasibility for their operation in-core.  The research will be carried out in the School of Engineering in close collaboration with our industrial partners: National Nuclear Laboratory, European Thermodynamics Ltd, National Space Centre and Space Park Leicester.  The project will begin with a rigorous systematic literature review on the investigated topic, followed by comprehensive multi-physics modelling to evaluate and trade-off novel low power in-core thermoelectric space reactor design concepts. An experimental campaign on candidate thermoelectric materials will be carried out to facilitate initial experimental proof of concept work. Findings are expected to be orally presented at international conferences and published in high-ranked journals. | | |