Scientia
SEPTEMBER 2025

Professor Hans Haubold
Professor Arak Mathai

A Summer House and the Sun: 50 Years of Space Science with the UN

doi.org/10.33548/SCIENTIA1320

EDUCATION & TRAINING

From a summer house just outside of Berlin, to the establishment of educational centres across the world —Professors Hans Haubold and Arak Mathai have overseen the remarkable development of space science over the last half-century. Their early research into the curious solar neutrino problem in the 1970s spawned several books and a large volume of academic literature exploring the inner workings of our Sun.

Developments in the mathematics of fractional calculus and special functions then helped to facilitate extensive studies of space and our solar system. Over the last 30 years, under the umbrella of the United Nations, space science has boomed, with 7 new centres set up across the globe and over 20 dedicated workshops arranged. A new generation is being trained to tackle the mysteries and challenges presented to us by outer space.

Cite as SD/Haubold/A Summer House and the Sun: 50 Years of Space Science with the UN/September 2025/1320

Einstein's Summer House and The Beginning of UN Space Science

In 1979, theoretical physicist Hans-Jürgen Treder acquired a summer house just outside of Berlin, previously belonging to a certain Albert Einstein. He managed to secure it specially for a celebration of what would have been Einstein's 100th birthday. In his honour, Treder founded the Albert Einstein Laboratory of Theoretical Physics based at the old summer house. Under Treder's directorship, this centre would tackle a variety of topics in astrophysics and solar science until 1992, when it was absorbed into the new Albert Einstein Institute in Potsdam. Across its lifetime as a research centre, the little summer house was a source of high-quality research. But, perhaps more importantly, its activities sowed the seeds for an even greater, more widespread legacy.

Since 1974, Professors Hans Haubold and Arak Mathai have been central figures in the establishment of a global research, teaching, and education programme in space science, and they trace the roots of their involvement to Treder and his laboratory. Work conducted over a period of 50 years has culminated in the organisation of more than 20 workshops and the establishment of 7 different centres across the globe dedicated to the development of space science. In a recent article, the two physicists recounted the remarkable history of how the modern space science research community, as overseen by the UN, developed from Einstein's humble summer house.

Something's Wrong with the Sun

In 1974, Treder suggested that Haubold and Mathai research a particularly perplexing problem in solar science that had stubbornly resisted being solved for a number of years. In the late 1960s – deep within an old goldmine in South Dakota– an experiment was conducted to measure the number of neutrinos produced by nuclear fusion in the Sun. Fusion reactions are what keep our star burning bright. In these reactions, isotopes of hydrogen –the most abundant element in the universe– are fused together into helium, releasing energy which prevents the Sun from collapsing due to its own gravity. As a byproduct, this process produces a particle called the electron neutrino. This particle is ghostly and almost undetectable, since it has a very low mass and rarely interacts with more ordinary kinds of matter. It would be expectable to see an unimaginably large number of neutrinos from the Sun pass through the Earth, but when the results of the experiment were analysed, there was something very strange about them. It seemed as though the Sun was producing too few of these particles. In fact, it seemed that almost exactly a third of the expected neutrinos were detected.

Following its discovery, this "solar neutrino" problem persisted for over 25 years. Haubold and Mathai took an interest and spent a number of years conducting detailed research to develop our understanding of the internal structure of the Sun, and the nuclear reactions that take place within its core. They took inspiration from the historical Einstein and the events leading to the development of quantum mechanics in the early 20th century. As physicists wrestled with strange new results from the quantum world, it was suggested that significant progress would not be made without the development of new mathematical techniques. In the following years, matrix mechanics became the foundational framework which is now used universally in the study of the quantum world. Using that episode in history as an example, Haubold and Mathai began developing the mathematics of fractional calculus. In regular calculus, you can only differentiate a function an integral number of times: the first derivative, second derivative, etc. Fractional calculus, however, posits the existence of derivatives "in between" the integral ones. Haubold and Mathai found that fractional calculus provided a valuable framework for understanding the diffusion processes occurring within the Sun's core.

With Treder's guidance, the two wrote a series of books compiling the key results and methods of fractional calculus, and its application to astrophysics. They provide an indispensable guide for budding researchers in the field of nuclear and neutrino astrophysics.

From Research to Training a New Generation of Space Scientists

The solar neutrino problem would not be solved until 2002, using a mechanism proposed by the Italian physicist Bruno Pontecorvo. He hypothesised that it was possible for electron neutrinos to transform into two other kinds of neutrino –the mu and tau neutrinos. This idea of neutrino oscillation predicted that, as they travelled, the electron neutrinos produced in the Sun would morph into the two other types. This meant that by the time these particles reached the Earth they were no longer solely electron neutrinos, but an equal mix of the three different kinds. Haubold and Mathai's books recount this historic journey, whilst also exploring the mathematics needed to understand solar structure and nuclear reactions.

Following their own research in solar science, both Haubold and Mathai became increasingly involved in the general teaching and education of the growing field. One of their longest projects has been the development of the Centre for Mathematical Sciences in Kerala, India, into an advanced and respected institute for mathematics and space science. From 1982, Haubold and Mathai began discussions on how research, teaching, and education should be conducted in such a dedicated institution. In 1985, Mathai became the Director of the institute –a position he still holds today. Across his tenure, he has taught a detailed educational programme on important aspects of space science, with emphasis on some of his own fields of expertise in fractional calculus, astrophysics, and special mathematical functions.

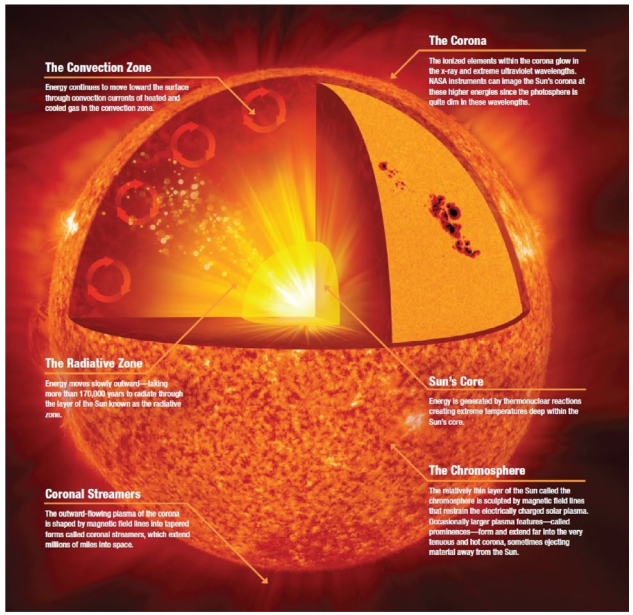
Space Science Goes Global

In 1988, Haubold relocated to New York to accept a position with the Outer Space Affairs Division of the UN. This was a global operation and Haubold was involved in setting up regional centres for space science across the world. Seven centres were established in China, India, Morocco, Nigeria, Brazil, Mexico, and Jordan. One of the most important tasks was to determine a curriculum suitable for the students in these centres. Together, drawing on their past experiences, Haubold and Mathai helped to write three new textbooks. These could be used to help teach some of the core skills needed for studies in space science, including the fundamentals of Linear Algebra, Probability, and Statistics. These were made openly available for the new regional centres to use in their educational programmes.

As well as the education of future space scientists, the UN division was also tasked with determining the direction of research. Four initial workshops were organised, one in each corner of the Earth, to gather experts in the field and identify research topics that should be pursued by the different regional centres. Since the initial workshops, more than 20 have been organised under the umbrella of the UN and have brought together space scientists from all over the world. One of the key discussions involved deciding which areas of space science were the most pressing for global development. Space weather was deemed integral to this, and subsequently several more international workshops were organised devoted to that specific field.

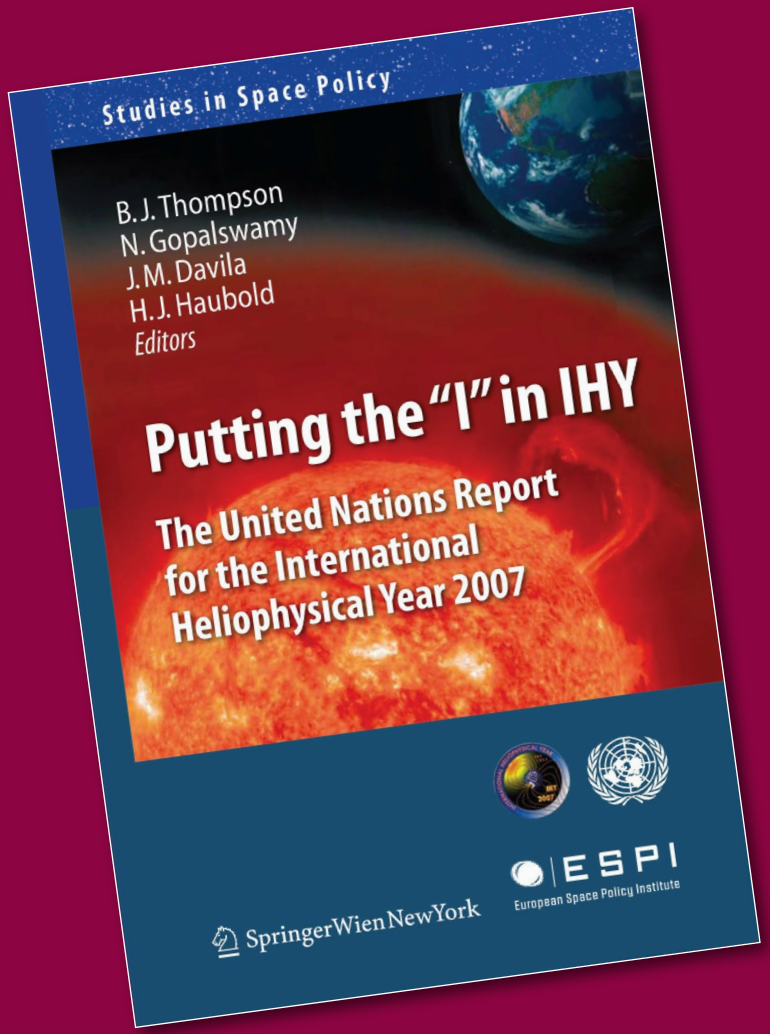
Outer Space and Our Future

For 50 years, Haubold and Mathai have been at the centre of developments in the research, teaching, and education of space science. Following their key contributions in the field of solar astrophysics, specifically the study of neutrinos and nuclear reactions in our Sun, they have devoted themselves to the establishment of new learning centres. They have seen the resolution of the solar neutrino problem that originally captured their attention, and they have helped to set up foundational curricula for mathematics and space science institutes across the globe. These will enable a new generation of space scientists to grow and eventually take on challenges in a variety of subfields, including space weather, climate, theoretical astrophysics, and many more. In future years, Haubold and Mathai also look forward to the construction of an Albert Einstein Discovery Centre in his hometown of Ulm. Such a centre would serve to honour the great physicist, educate the public on his unique achievements, and harken back to his summer house which facilitated the growth of an international community of space scientists.



Article written by Matthew Davies, PhD

MEET THE RESEARCHERS



Professor Hans Haubold
Outer Space Affairs Division, United Nations, New York, USA

Professor Hans J. Haubold is a theoretical astrophysicist at the Office for Outer Space Affairs division of the United Nations. He earned his PhD in 1980 while working on stellar astrophysics in Germany. He took a keen interest in studies of the internal structure of the Sun and helped to develop new tools within the fields of fractional calculus and special mathematical functions for this purpose. Since 1990, Prof Haubold has worked within the UN to develop the teaching, education, and research of space science across the world. He played a fundamental role in the establishment of regional space science centres in 9 different countries. He also has an interest in the history of science and has actively promoted the contributions of Einstein and Michelson to physics. During his career, he has published over 400 academic works and 15 books.

CONTACT
hans.haubold@gmail.com

FURTHER READING

H Haubold, A Mathai, Pictorial and Documentary Guide for Research, Teaching, and Education through Astronomy, Physics, and Mathematics Pursued under the Umbrella of the United Nations (1974-2024), *Creative Education*, 2025, 16 (7), 964-992. DOI: 10.4236/ce.2025.167061.

H Haubold, History and Education of the Albert A. Michelson Exhibition Developed at the Occasion of the Einstein Centenary Berlin 1979 and the Michelson Colloquium Potsdam 1981*, *Creative Education*, 2024, 15, 1166-1194. DOI: 10.4236/ce.2024.156071.

Professor Arak Mathai
Department of Mathematics and Statistics, McGill University, Montreal, Canada

Arak M. Mathai is an emeritus professor in the Department of Mathematics and Statistics at McGill University. Born in Kerala, India, Prof Mathai earned a Commonwealth scholarship to study at the University of Toronto where he obtained his PhD in 1964. Prof Mathai's work has been foundational in the fields of statistics, fractional calculus and special functions of mathematics – particularly their applications to astrophysics. He has published over 300 research articles and 37 books. Since 1985, he has also served as a founding director of the Centre for Mathematical Sciences in Kerala developing its curriculum and establishing it as a respected institution. It has been named the A. M. Mathai Centre in his honour. He is a visiting professor at universities around the world and regularly speaks at conferences about his work.

CONTACT
directorcms458@gmail.com