The Szekeres Medal
Citation for Mathai Varghese

The George Szekeres Medal is the Australian Mathematical Society's most prestigious medal, recognising research achievement and an outstanding record of promoting and supporting the discipline. Mathai Varghese's sustained contributions in both of these areas over a long time make him a most deserving recipient of the Szekeres medal.

Mathai has made significant contributions to geometric analysis and to mathematical physics. Among the highlights are his co-invention of Projective and Fractional Index Theory, which has recently been generalized to certain infinite dimensional manifolds and for the Mathai-Quillen formalism in Index theory and topological field theories. He is also renowned for his research in String Theory, T-duality in a background flux with a change of topology and novel applications to condensed matter physics.

He has held the position of Vice-President (Annual Conferences) of AustMS, supervised ten PhD students and ten masters students to completion and mentored fifteen postdoctoral fellows. Most of these students and mentees have moved on to positions in good institutions in Australia and overseas.

Research achievements.

Mathai Varghese is recognized as a world leader in index theory, noncommutative geometry, and mathematical physics. He has made fundamental contributions to these areas of mathematics.

In his joint work with Quillen, Mathai established a refinement of the Riemann–Roch formula. The Mathai–Quillen formalism has had a huge impact on index theory and its applications.

The Novikov conjecture is a central problem in topology of manifolds. Roughly speaking, the conjecture states that all manifolds are rigid at the infinitesimal level. Mathai proved a beautiful theorem stating the Novikov conjecture is also true for all group cohomology classes in the ring generated by degree two group cohomology classes.

In his ongoing joint work with Melrose and Singer, Mathai initiated index theory for projective families of elliptic operators, where the index is an element in the twisted K-theory of the parametrising space and established the relevant index theorem in the case when the Dixmier-Douady twist is torsion and when the Dixmier-Douady twist is decomposable. This included recognising many interesting non-torsion twisting classes.

In further joint work with Melrose and Singer, Mathai introduced the notion of a projective differential operator, which is a nontrivial generalization of a differential operator. He defined ellipticity for such a projective differential operator and proved the index theorem for projective elliptic differential operators on compact manifolds, solving a long-standing open question.

Jointly with Melrose, Mathai proved a converse to Egorov's theorem thus establishing that the automorphism group of pseudodifferential operators is the group of projective invertible Fourier Integral operators.

Recently, in joint work with Fei Han, Mathai generalized his previous work on the fractional index theorem to the infinite dimensional loopspace of a manifold, where the index was shown to be a modular form over the rational numbers.

One beautiful example of Mathai's work is T-duality, a rather mysterious set of relations between pairs of distinct manifolds that has its origins in mathematical physics, specifically in string theory. Topological features of the manifolds may be described by so-called characteristic classes in cohomology. But the manifolds can carry supplementary structures called ``twistings'' that are also described by characteristic classes. Mathai and his collaborators demonstrated that in T-duality the two different types of characteristic classes are exchanged, and in this way twistings become essential to the precise mathematical formulation.

Promoting and supporting the discipline.

Mathai has an excellent record of promoting and supporting the discipline. As mentioned above, he has successfully supervised ten PhD students and ten MPhil students. Many of the latter have obtained PhD admission with scholarships at top universities overseas. Mathai has also mentored fifteen postdoctoral fellows who went on to obtain further postdoctoral positions or continuing positions.

Mathai was the Vice-President (Annual Conferences) for the Australian Mathematical Society from 2006 to 2009 and a member of the Program Committee for the Conferences between 2007 and 2010. A highlight occurred in 2009 when an agreement was signed with Clay Mathematics Institute to fund three plenary speakers Terry Tao from UCLA, Danny Calegari from the University of Chicago and Mohammed Abouzaid from MIT. That meeting of AustMS meeting was the first to attract over 400 participants.

Mathai has been the Director of the Institute for Geometry and its Applications at the University of Adelaide since 2009 and has successfully obtained funding for conferences and to stimulate research in Adelaide every year.