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Structural Properties of Modules of Rectangular Multivariate Harmonic polynomials

Modules of rectangular $k \times n$ -variate diagonal harmonic polynomials (for the symmetric group) afford two commuting actions, one for the general linear group GL_k , and one for the symmetric group S_n . These modules are a broad generalization of similar modules considered in the seminal work of Garsia and Haiman in relation to S_n -diagonal coinvariant spaces. These recent extensions make apparent deep ties between many areas of research such as: Rectangular Catalan Combinatorics, Homology of (m, n) -Torus Knots, Algebraic Geometry (Hilbert Scheme of points in the plane), and Theoretical Physics. We will describe many structural properties of the aforementioned $k \times n$ -variate modules, which characterize their decomposition into irreducibles for both actions. If time allows, we will also describe intriguing links with operators that occur in the "Delta conjecture" of Haglund et al.