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Second Order Freeness and Compound Wishart Matrices

In 1986, D. Voiculescu introduced the R-transform of a random variable. The coefficients of this power series, now called free cumulants, were shown in 1994 by R. Speicher to have a combinatorial interpretation using non-crossing partitions. In 2004, A. Nica and I showed that the covariance, when suitably magnified, of the traces of some standard families of random matrices has a limiting value that can be interpreted in terms of non-crossing annular partitions. Indeed the order of elements in a block of a partition is now significant and the relevant concept is a non-crossing permutation. These non-crossing annular permutations give rise to second order cumulants which in turn form the basis of second order freeness. We shall give a number of natural examples of families of matrices that exhibit second order freeness.

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