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Large deviation function for the number of eigenvalues of sparse random graphs inside an interval

We present a general method to obtain the exact rate function $\Psi_{[a,b]}(k)$ controlling the large deviation probability Prob$[\mathcal{I}_N[a,b] = kN] \asymp e^{-N\Psi_{[a,b]}(k)}$ that an $N \times N$ sparse random matrix has $\mathcal{I}_N[a,b] = kN$ eigenvalues inside the interval $[a,b]$. The method is applied to study the eigenvalue statistics in two distinct examples: (i) the shifted index number of eigenvalues for an ensemble of Erdös-Rényi graphs and (ii) the number of eigenvalues within a bounded region of the spectrum for the Anderson model on regular random graphs. A salient feature of the rate function in both cases is that, unlike rotationally invariant random matrices, it is asymmetric with respect to its minimum. The asymmetric character depends on the disorder in a way that is compatible with the distinct eigenvalue statistics corresponding to localized and delocalized eigenstates. The results also show that the level compressibility κ_2/κ_1 for the Anderson model on a regular graph fulfills $0 < \kappa_2/\kappa_1 < 1$ in the bulk regime, in contrast to the behavior found in Gaussian random matrices.