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*Counting Connected Graphs using Erdős Magic*

Let $C(k,l)$ be the number of labelled connected graphs with $k$ vertices, $k-1+l$ edges. We employ random graphs and breadth first search techniques to find the asymptotics of $C(k,l)$ whenever $k,l$ both tend to infinity. We further analyze the joint distribution of the number of vertices and edges of the "giant component" of Erdős and Renyi. We further consider randomized algorithms that (for "most" $k,l$) efficiently generate uniformly distributed connected graphs with these parameters.

At heart we have a tilted balls-into-boxes model. We place $k-1$ balls into $k$ bins, ball $j$ going into bin $i$ with probability $p(1-p)^{i-1}/(1-p^k)$, a truncated exponential where we think of $p$ as the tilt. With $Z_t$ balls in bin $t$ the "queue walk" has $Y_0=1$, $Y_t=Y_{t-1}+Z_t-1$ and hence $Y_k=0$. We analyze (for appropriate $p$) the probability that the walk has $Y_t>0$ for all $0\le t<k$.