Neuronal avalanches in condensed grey matter

Condensed matter physics has provided a framework from which to interpret experiments on ensembles of neurons. Using this framework, it has been shown that cascades of activity among neurons can be described by the same equations that govern avalanches in granular materials, complete with power laws, an exponent relation and a universal scaling function. These “neuronal avalanches” also indicate that the brain may be operating near a critical point where many of its information processing functions are optimized, analogous to peaks in susceptibility and correlation length seen at a continuous phase transition. Yet the condensed matter framework may have its limits. The most recent experiments have revealed that these neuronal networks are far from lattice-like: they have hubs and clusters containing long-distance connections. Moreover, their connections are directional and not merely coupling constants like those found in the Ising model. A major challenge for future work will be to adapt the fruitful tools of condensed matter physics to the complex connectivity found in living neural networks.

John Beggs, Indiana University Physics