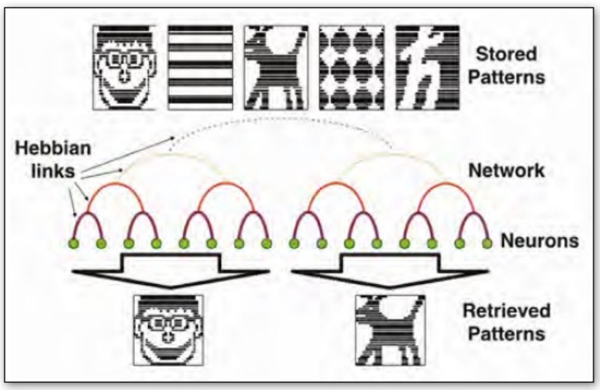
Highlights from European journals

MATHEMATICAL PHYSICS

Neural networks beyond **the mean-field paradigm**

The seminal paper "Neural Networks and physical systems with emergent collective computational abilities" by Hopfield (1982) and its statistical mechanical treatment by Amit, Gutfreund and Sompolinsky (1985) still play as *"harmonic oscillators"* in Artificial Intelligence: crucially, in their picture, "associative memory" emerges as a collective feature of neurons. Due to mathematical constraints, this paradigmatic formalisation relies on the so-called "mean-field" approximation: each neuron interacts with all others in the network, regardless of their reciprocal distance. As a (non-obvious) consequence, the network performs "serial processing": it is able to retrieve one pattern of information per time.



▲ Schematic of a hierarchical neural network (center): five stored patterns (top), with two retrieved (bottom).

Here we show a way, based on a hierarchical underlying topology (see figure), to overcome mean-field limitations, thus accounting for neuronal distance in the network (this also allows for dilution as neurons too far away do not interact). Remarkably, simply introducing a metric (that is a biological must) enables the network to spontaneously switch from serial processing to parallel processing: it can retrieve several patterns of information simultaneously. These emergent multitasking features characterize a novel generation of neural networks, which better capture real brain behaviour. ■

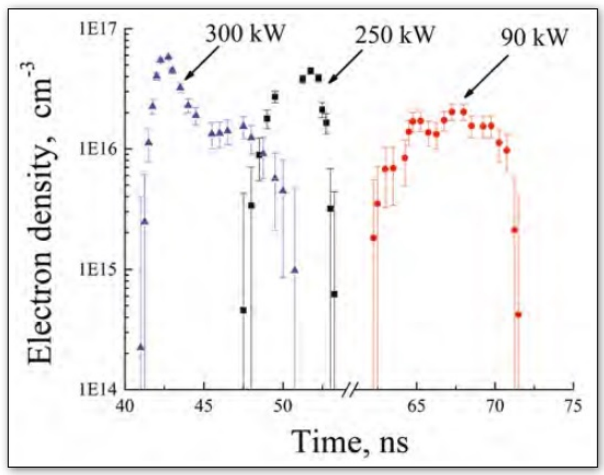
▮ **E. Agliari**, **A. Barra**, **A. Galluzzi**, **F. Guerra**, **D. Tantari** and **F. Tavani**,
'Metastable states in the hierarchical Dyson model drive parallel processing in the hierarchical Hopfield network',
J. Phys. A: Math. Theor. **48**, 015001 (2015)

PLASMA PHYSICS

Plasma density evolution in a microwave pulse compressor

Microwave plasma discharges have been widely investigated for many years; there is, however, a subject that is insufficiently studied. It is the plasma formation at the initial – nanosecond time-scale – stage of the high-pressure discharge in a resonant cavity and its interrelation with the process of microwave energy release from the cavity that goes out of resonance during the plasma generation. This subject directly concerns the operation of microwave compressors using commercial magnetrons and klystrons for short-pulse high-power microwave generation. In this work, for the first time, spectroscopic measurements were performed to investigate nanosecond dynamics of the plasma density in the S-band compressor with laser triggering. For pressurized helium filling the compressor cavity and switch, the plasma density was evaluated from the shapes of the 3888.65 Å and 4471.5 Å He I spectral lines.

▼ Plasma density vs. time after the laser triggering for different microwave output.



The measured evolution of the density was found to correlate with the peak power of the compressor output pulse and efficiency of the stored microwave energy extraction. With increasing microwave output, the plasma appears earlier in time after the laser beam enters the system, the plasma density rises more steeply, and it reaches higher values. ■

▮ **L. Beilin**, **A. Shlapakovski**, **M. Donskoy**, **T. Queller** **and Ya. E. Krasik**,
'Plasma density temporal evolution in a high-power microwave pulse compressor switch', *EPL* **109**, 25001 (2015).