



By embarking on construction of two major experimental fusion facilities, ITER (left) and LMJ (right), France, and CEA, find themselves in the forefront of development, for the two major confinement methods, magnetic on the one hand, inertial on the other.

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II. THE SUN ON EARTH?

Whereas, at present, nuclear power generation relies, on Earth, on the *fission* of nuclei, which is a marginal process on a cosmic scale, thermonuclear *fusion* reactions are active in practically all stars. By embarking on construction of two major experimental fusion facilities, ITER and LMJ, incorporating different design concepts, France finds itself in an exceptional position. Barely over twenty years after gaining an understanding of the fusion mechanisms inside the Sun, research workers are setting out to draw on this to achieve, on Earth, thermonuclear fusion reactions. As emphasized by Yanick Sarazin, taking the example of turbulence, a universal, highly complex phenomenon, a very large number of the properties of hot plasmas still require a better understanding, and have yet to be mastered, demonstrating the importance of fundamental research in the progress towards domestication of thermonuclear energy.

Every gram of plasma in the Sun's core generates about two millionths of a watt. It was utterly imperative to "do better" than this, by going for a reactive mix of deuterium and tritium, which is not to be found inside the Sun. Economic viability for fusion sets a minimum value (of the order of $10^{20} \text{ m}^{-3} \cdot \text{s}$) for the product of the energy confinement time, τ_E , and density, in terms of the number n of particles per cubic meter of plasma. Gravitational confinement being out of the question on our earthly scale, two confinement and burn-regime modes are on hand, as rival candidates.

The first one is near-continuous (long τ_E); a very hot, highly dilute (low n) plasma is confined by means of a complex magnetic structure, of large volume: this is the path of *magnetic-confinement fusion*. Michel Chatelier and Philippe Magaud describe the advances, over 30 years, of the physics and technology of tokamaks, leading to the decisive stage of demonstration of the mastery of burning plasma, which is to be assigned to ITER.

The second regime is discontinuous, and repetitive; fusion, of an explosive character in this case, is achieved in a tiny volume of plasma, impelled into extremely rapid compression (short τ_E) to heat it and compress it very strongly (high n), in order to release enough energy before the mix disperses: this is the path of *inertial-confinement fusion*. This requires an energy input of the order of one megajoule, entrusted to the 240 laser lines in LMJ.

Guy Schurtz, Claude Rullière, Philippe Baclet and Jacques Tassart describe the concatenated scientific and technological requirements, from the microscopic to the macroscopic, if the outcome is to achieve fusion in plasmas denser and hotter still than those in the Sun's core. The flexibility of lasers, as carriers of energy for plasma-generation purposes, opens up the disciplines involved in inertial-confinement fusion to a number of fields in the physics of matter in extreme conditions.

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