Chasing the sun

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Imagine the interior of a fusion reactor: tightly sealed within a vacuum container, a blob of plasma swirls chaotically at speeds approaching that of light, burning at temperatures hotter than the sun. Such an environment seems inaccessible, and yet gaining detailed insights on the plasma behaviour is paramount if we hope to achieve a sustained fusion reaction, thus getting one step closer to successfully employ a reliable, clean and abundant source of energy.

By solving the intricate equations describing burning plasma, mathematics can help us take a peek at what occurs inside a reactor. Given the complexity of the physics involved, however, even the most powerful computers might require days, weeks, even months, to provide accurate solutions. In my research, I work to drastically reduce the time necessary to compute such simulations, by employing parallelisation techniques. These consist in splitting the main problem into smaller ones that can be solved concurrently. The innovative aspect lies in how this subdivision is made: each processor captures the evolution of plasma within a prescribed time interval, and these partial contributions are then combined together to recover the complete solution. This sounds counterintuitive, since each bit of the solution depends on what happened beforehand, which is unknown at first. Nonetheless, the required initial conditions can be guessed and refined during the computations, in order to achieve the desired result.

Time-parallelisation would benefit not only plasma research, but also countless other fields where numerical simulations play a fundamental role in designing innovative products.