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Research article:

Magnetic field simulations of the GOLEM tokamak via the NICE code

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About the author

Matyáš Pokorný is a high school student of the French branch of the Jan Neruda Gymnasium in Prague, where he's currently starting his final year of studies. He has been engaging in research related to thermonuclear fusion at the GOLEM tokamak (FNSPE CTU) for more than two years. His latest work, focusing on the measurement and simulation of plasma position at GOLEM, has won 3rd place in the České Hlavičky competition. The presented paper is an excerpt from this work. Matyáš Pokorný also participates in various different physics-related activities, including correspondence seminars or summer programs. Apart from research, Matyáš Pokorný also practises breakdancing at a competitive level. In the future, he aspires to study at the EPFL university and to engage in research taking place at the TCV tokamak.

Explanation for general audience

Thermonuclear fusion is the physical process that allows the sun to produce energy. It is, essentially, the opposite of nuclear fission—during fusion, the nuclei of two lighter atoms merge to form a nucleus of a heavier atom. This physical process can produce energy under certain extreme conditions. To do so on Earth, the most effective way to achieve energy production via fusion seems to be heating up the fusion fuel (usually hydrogen isotopes) to tens of millions °C, which necessarily renders the fuel's state plasmatic. Due to the plasma's extreme temperature, confining it for a sufficiently long period of time poses a great challenge.

It is the role of the so-called tokamak to confine this plasma and gather the energy produced by fusion. The tokamak confines the plasma with a strong and complex magnetic field. At present, no tokamak was able to achieve net energy gain, mainly due to physical and technological challenges posed by the magnetic field's complexity, by the plasma's chaotic nature and by plasma-material interaction. Numerical simulations are commonly used to help address these issues.

In this paper, we put into operation the so-called NICE code for the case of the GOLEM tokamak (FNSPE CTU, Prague). This code allows us to simulate the tokamak's magnetic field and plasma under different configurations of the plasma's force balance. For the first time, we enable the simulation and visualization of GOLEM's magnetic field and, as NICE is the first numerical code put into operation for the case of GOLEM, we lay the basis for the creation of a future complex simulator, allowing for more comprehensive GOLEM simulations.