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Scientific and Technological Challenges of Diagnosing Burning Plasmas[1]

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Research in magnetically confined fusion is now approaching a major milestone which is in evaluating and controlling burning plasma conditions. This milestone will be first met in the ITER experiment, presently being built in Cadarache, France through an international partnership, which includes China, the European Union, India, Japan, South Korea, Russia and the United States. In order to achieve its mission of achieving burning plasma conditions, and possibly ignition, a comprehensive set of scientific instruments (diagnostics) is being planned. That set represents the culmination of more than 50 years of development and research. More than 40 plasma parameters will be measured, including many which will be directly controlled. Some of these measurements will be done for the first time, such as probing the production, distribution and behavior of fusion produced, i.e. alpha particles, a key element in sustaining the fusion reaction process. These measurements will need to be done in a hostile environment, where a large nuclear radiation field, substantial direct particle flux, long pulse length and lack of direct access will bring severe constraints. Furthermore, the needs of the experiment will demand high reliability, low maintenance and the ability to retain a good calibration over a long period of time. We will review the challenges of the task and the opportunities for scientific breakthroughs from these state-of-the-art diagnostics instruments, as they pertain to the specific context of burning plasma conditions, together with examples of where these measurements will directly impact our scientific understanding and ability to control these conditions.

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