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Time-dependent SOLPS-ITER simulation for actuator design and system identification

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Time-dependent SOLPS-ITER simulations have been extensively applied to various problems such as actuator design, feedback control through system identification, and physical interpretation of dynamic problem. Most SOLPS-ITER simulations focus on steady-state solutions, and the EIRENE module, a neutral solver, couples in a time-independent mode assuming quasi-relaxation within time step of 1e-3 sec, which is several orders of magnitude larger than the fluid plasma time step. We made the neutral time step the same as the plasma time step and performed a full time-dependent simulation considering the neutral census data. This feature is applied to the design of SPARC's Louvre structure [1], which controls divertor plasma parameters by regulating neutral conductance from the divertor to the pump. The response of the plasma and neutral parameters can be captured with the timescale that enables us to design the actuator considering time-dependent control capability. Feedforward SOLPS-ITER simulations were carried out in KSTAR using the recently developed time-dependent gas puff feature, and system identification based on these data was carried out with DMD and SINDy. Through this reduced model, feedback control of upstream density was performed under IPS environment. The target flux bifurcation observed in the KSTAR experiment is a dynamic problem, and a time-dependent SOLPS-ITER simulation was performed for the physical interpretation. It was found that X-point radiation was the main cause, and the bifurcation time scale observed in the experiment was also reproduced in the simulation within a factor of 2. The validity of data-driven system identification and feedback control, including bifurcation, is also tested.

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[1] A. Q. Kuang, et al. J. Plasma Phys 86.5 (2020)

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