Data science for the prediction of particle transport induced by energetic particle modes

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Energetic particles naturally exist in tokamaks due to either fusion reactions or external heating such as ICRH or NBI. These energetic particles need to be well-confined in order to transfer their energy to thermal particles and achieve this way a regime with self-sustained fusion reactions. However, energetic particles excite modes that tend to de-confine the particles themselves. This is the reason why energetic particle mode excitation and saturation need to be understood and controlled. Nevertheless, determining whether energetic particles are confined or not in the presence of instabilities and determining the characteristic of particles that are lost are not easy tasks, neither numerically due to the complexity of simulations, nor experimentally due to the lack of data. In this presentation we show how energetic particle transport is analysed and open new routes for the use of deep learning to predict the transport and characteristics of energetic particles in real scenarios. For this purpose, we focus on a special class of energetic particle modes, called energetic geodesic acoustic modes (EGAMs) [1, 2]. Because these modes are axisymmetric, they have been usually believed to play little role on the transport in a tokamak. Nevertheless, it was observed experimentally [1] and numerically [3] that particles can be de-confined in the presence of EGAMs. We explain in this presentation the underlying mechanisms of the role of EGAMs on transport and show they can actually have an impact, both directly on the trajectories of particles [4] and indirectly on the turbulent transport [5, 6, 7]. Finally, the need for algorithms based on deep learning techniques is evidenced.

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