Insights from collisional-radiative modeling applied to disrupting ITER-like fusion plasmas

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Tokamak disruption events, in devices such as ITER, can generate relativistic ($E > 1$ MeV) runaway electrons that have the capacity to cause significant damage to plasma-facing components. A primary approach currently being considered for ITER is to inject large amounts of high-Z impurities, such as argon, into the plasma to mitigate the runaway damage. It is also known that injection of argon in current experiments can, and have, produced robust runaway plateau. It is an outstanding physics question when the impurity injection is helping and when it is worsening the situation.

A key process in tokamak disruption mitigation via impurity injection is the atomic processes that lead to radiative cooling of the plasma and the modification of runaway distribution in energy and pitch. In order to generate greater understanding of the impact of atomic processes on fusion plasmas, we have extended upon the popular FLYCHK collisional-radiative model, with focused additions made for modeling fusion plasma environments in which high-Z impurities are introduced and a minority high energy electron population is present.

Specific additions to our CR model include relativistic corrections for electron impact inelastic scattering cross-sections, as well as the evaluation of all rates over arbitrary, complex electron energy distribution functions commonly found in disrupting fusion plasmas. By accounting for these vital phenomena, we demonstrate predictive capability of the cooled quasi-steady-state of the post-disruption plasma. Further, it is shown that significantly different predictions are produced when relativistic corrections are employed, highlighting the importance of accurate atomic data in improving our understanding of fusion science.