New methods of neutron emissivity tomographic reconstruction for fusion plasma

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Reconstruction of the neutron emissivity distribution in fusion devices is a useful tool for retrieving information on spatially resolved fusion rates. The reconstruction is performed from a limited number of line-integrated quantities measured by a set of neutron detectors. Usually the coverage of a plasma cross-section is very sparse. Thus, the problem of tomographic reconstruction is very challenging due to its ill-posed character. Several approaches to the reconstruction of neutron emissivity in magnetic-confinement fusion devices have been developed.

In this work two recently developed methods are presented: (i) the method based on genetic algorithms (GA) and (ii) the method based on Metropolis–Hastings Monte Carlo (MC) algorithm.

GA are inherently parallel and the search is performed from a population of points. Therefore, the method has the ability to avoid being trapped in a local optimal solution. The developed MC method is based on a biased random walk. The algorithm generates pseudo-random samples within the domain that contains the solution. The properly chosen objective function ensures the convergence to the desired solution. The applied Metropolis–Hastings algorithm can overcome the problem of trapping of the random walk in local minima, because it offers a possible method for jumping out of them by accepting, with some finite probability, changes in the direction opposite to indicated by the objective function.

Both methods have been tested using a set of synthetic models. The methods have been validated in terms of accuracy, speed and resilience against the noise present in the line-integrated input data. The obtained results show that both methods provide accurate reconstruction results, comparable with those obtained by the standard methods routinely used for tokamak plasma (e.g. Tikhonov Regularization, Minimum Fisher Information, etc.)

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