A comparison of reconstruction methods for inferring the fast-ion distribution function from multiple FIDA measurements

L. Stagner and W.W. Heidbrink
University of California, Irvine, California 92697, USA

A.S. Jacobsen and M. Salewski
Technical University of Denmark, Department of Physics, DK-2800 Kgs. Lyngby, Denmark

B. Geiger, M. Weiland, and the ASDEX Upgrade team
Max-Planck-Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

The Fast-ion $D_\alpha$ (FIDA) diagnostic measures light that energetic particles emit in fusion plasmas. The diagnostic is sensitive to different velocity space regions depending on the viewing angle relative to the magnetic field.[2] Consequently, viewing chords that share a radial location give different, yet still valid, results. Velocity space tomography allows us to combine the rich information contained in FIDA spectra from these viewing chords to infer the complete local fast-ion distribution function from the different partial views.[1] Tomography involves solving a system of linear equations which are often ill-conditioned and consequently sensitive to measurement error. There are a number of ways to regularize these types of systems to make them amenable to physical solutions. These methods include Truncated Singular Value Decomposition (TSVD), Zeroth and First Order Tikhonov Regularization, the Maximum Entropy Method, and Minimum Fisher Information Regularization. The best regularization method is often application dependent. In this work we present a survey of the different regularization methods using realistic synthetic data to determine the most effective regularization method for velocity space tomography. Preliminary results show, for realistic distributions, that Minimum Fisher Information Regularization produces the best results. We also demonstrate the application of the described methods to real data to study the redistribution of fast-ions during a sawtooth crash at ASDEX Upgrade. An extension of velocity space tomography to allow for the inference of the full fast-ion distribution in constants of motion space will also be presented.
