Improved profile fitting and quantification of uncertainty in experimental measurements of impurity transport coefficients using Gaussian process regression

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The need to fit smooth temperature and density profiles to discrete observations is ubiquitous in plasma physics, but the prevailing techniques for this have many shortcomings that cast serious doubt on the statistical validity of the results. This issue is amplified in the context of validation of δf gyrokinetic transport models, where the strong sensitivity of the code outputs to input gradients means that inadequacies in the profile fitting technique can very easily lead to an incorrect assessment of the degree of agreement with experimental measurements. In order to quantify and rectify the shortcomings of standard approaches to profile fitting, we have applied Gaussian process regression (GPR), an extremely powerful nonparametric regression technique, to analyze impurity transport in high-performance Alcator C-Mod discharges. We show that these techniques can reproduce certain previous results while delivering more statistically-rigorous fits and uncertainty estimates for both the value and the gradient of plasma profiles with a vastly improved level of automation. More advanced applications of these techniques can allow for dramatic increases in the rate of convergence of uncertainty propagation for any code that takes experimental profiles as inputs. These new techniques for profile fitting and uncertainty propagation are quite useful and general, making them of great interest for wider use in fusion experiments and modeling efforts.