Abstract
Accurate treatment of fusion charged particle transport is important for understanding ICF ignition implosions as well as charged particle diagnostics. Over the years, many models have been proposed, each assuming different plasma regimes and having different validity constraints. Here we present a comparison of the most popular models and present a detailed analysis of their validity constraints. We present a comparison of the models of Landau/Trubnikov/Rosenbluth; Li and Petrasso; Brysk; Skupsky; Brown, Preston, and Singleton; and a Fermi-degenerate generalization of Li and Petrasso’s model. We propose methods of experimentally distinguishing stopping power models.

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Summary
- Stopping power models have (sometime strict) theoretical limitations.
- Different models model different physics, which have their own restrictions.
- Mutually valid models give inconsistent answers.
- Developed stopping power library (deeks) that implements many models with validity checking.
- Deeks can be used to help design experiments that will validate theory.
- Deeks can be used to aid interpreting detector data and used to infer experimental quantities.

Mathematical simplifications restrict validity
- Dielectric models expect (incident ion v) < (electron thermal v).
- Boltzmann models expect a large Coulomb logarithm.
- Neither happen consistently in ICF plasmas.
- Convergent models are currently restricted to Maxwellian distribution functions.

Mutually valid models can differ up to a factor of 2
- Even under mutually “valid” conditions, stopping power models do not agree.
- Both collisional and dielectric effect important.
- Ambiguity in Coulomb logarithm responsible for most of the variation.
- Convergent models seem to include collisional and dielectric effects correctly, but are currently restricted to Maxwellian plasmas.

Plasma Properties Limit Scope of Theory
- Statistical descriptions of a plasma depend on the plasma parameter (aka coupling parameter aka inverse particles in a Debye sphere) being small, the “weak coupling approximation.”
- We should be aware of when a plasma is no longer weakly coupled.
- Stopping power models make assumptions regarding the plasma’s distribution function (usually that it is Maxwellian).
- We should be aware of when a plasma is no longer Maxwellian, and use an appropriate (semi) Fermi degenerate model.

Validity map has complicated structure
- Regions of validity (shaded area) is valid.
- Previous models have taught caution in applicability of models.
- Additional work needed to get degenerate BPS-like model.
- Unanswered questions:
  - Is atomic structure significant?
  - Effect of magnetic field perturbations?
  - Ultimately need to experimentally measure the stopping power.

Experiments are needed to validate convergent model
- Charged particle transport is not a solved problem.
- Many (sometimes contradictory) models exist for different transport regimes.
- Implemented a library (deeks) that contains all major models with significant validity checking.
- Useful for designing experiments to measure/differentiate between models.

Conclusion
- Charged particle transport is not a solved problem.
- Many (sometimes contradictory) models exist for different transport regimes.
- Implemented a library (deeks) that contains all major models with significant validity checking.
- Useful for designing experiments to measure/differentiate between models.