Comparison of realistic heavy-ion transport models: Collision integral in the presence of momentum dependent interactions

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Past TMEP investigations

Publications:

1) J. Xu et al., “Understanding transport simulations of heavy-ion collisions at 100A and 400A MeV: Comparison of heavy-ion transport codes under controlled conditions, Phys.Rev.C 93, 044609 (2016)

   - first assessment of differences among transport model predictions

2) Y.X. Zhang et al., “Comparison of heavy-ion transport simulations: Collision integral in a box”, Phys.Rev.C 97, 034625 (2018)

   - comparison of various approaches for solving the collision integral for elastic collisions in a box; study of the effectiveness of different Pauli blocking algorithm in preserving the Fermi-Dirac character of nucleonic distributions

3) A. Ono et al., “Comparison of heavy-ion transport simulations: Collision integral with pions and Δ resonances in a box”, Phys. Rev. C 100, 044617 (2019)

   - no mean-field, no Pauli blocking; comparison to exact results for equilibrium quantities and rate equation

4) M. Colonna et al., “Comparison of heavy-ion transport simulations: Mean-field dynamics in a box”, Phys.Rev.C 104, 024603 (2021)

   - mean-field (momentum independent) response for isospin symmetric nuclear matter (first sound propagation)

5) H. Wolter et al., “Transport model comparison studies of intermediate-energy heavy-ion collisions”, Prog. Part. Nucl. Phys. 125, 193264 (2022)

   - progress report + model (code) descriptions (26 of the most widely used transport models)

6) J. Xu et al., “Understanding pion production from transport simulations of heavy-ion collisions at 270A MeV”, PRC 109, 044609 (2024)

   - pion production in HIC; common initialization, all ingredients of the transport model have been included; momentum independent interaction

Choice of reaction (s)

Criteria:

1) Require modest/moderate computational resources (in order to encourage participation)

2) Availability of extensive/complete experimental data (it may be timely to perform some real analysis), availability of support from experimental side

3) Restrict only to nucleonic observables (as pionic ones come with additional complications)

4) Some outstanding problem/contradictory results exists at present

^{108}Sn+^{112}Sn and ^{132}Sn+^{124}Sn at 270 MeV/nucleon is ideally suited

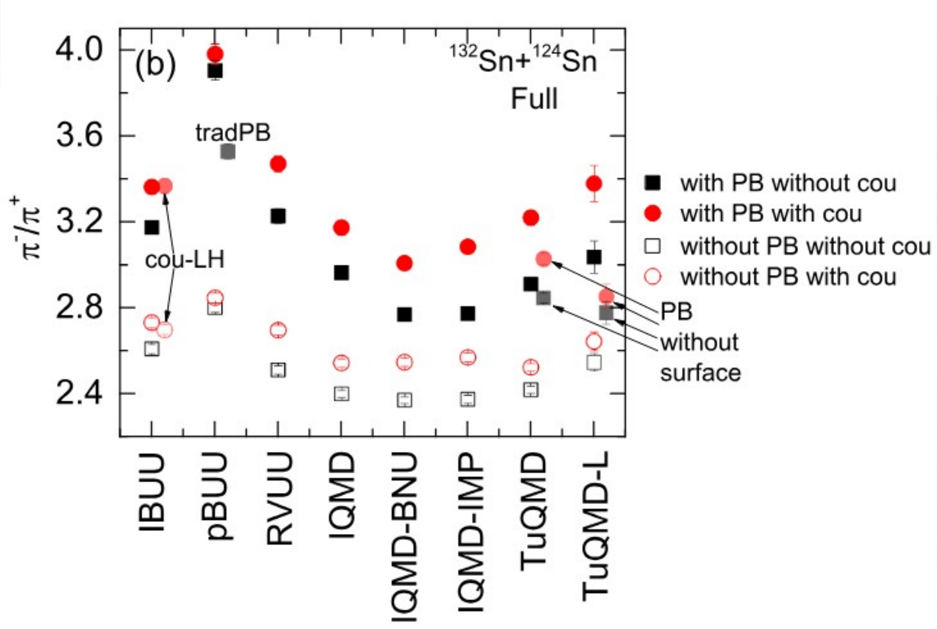
List of issues worth addressing: - different models seem to require different in-medium cross-sections (ImQMD, dcQMD, AMD)

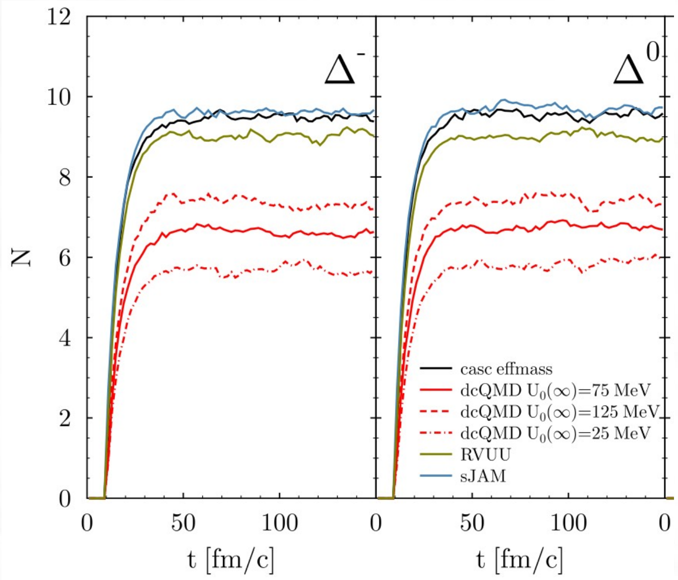
- weaker momentum dependence of the isoscalar optical potential, compared to empirical one (ImQMD, dcQMD, pBUU?)
- conflicting values for the neutron-proton effective mass splitting (ImQMD, dcQMD)
- applicability of the coalescence invariance hypothesis (dcQMD)

What would be a realistic assignment?

Use experience from last published study (J. Xu et al., PRC 109, 044609)
and forthcoming one

- no calculations with Coulomb or Pauli blocking switched off required
- finetune optical potential over the entire range of probed momenta





What would be a realistic assignment?

Use experience from last published study (J. Xu et al., PRC 109, 044609)

Phase 0 (?): Prove that models are compatible with results of PRC 109, 044609
- provide initial state to avoid differences originating at that level

Phase 1: Test of momentum dependent interactions
- provide initial state; constant/isotropic cross-sections; switch off inelastic channels
- several cases (at least two: 1) with and 2) without threshold effects;
  1) with and 2) without momentum dependent Lane potential)

Phase 2: Comparison to experimental data
- 1) provide initial state 2) own initial state, but subject to certain restrictions (charge radius, neutron skin, other)
- 2) realistic elastic cross-sections: 1) vacuum and 2) medium modified

- extract in-medium cross-sections, effective masses from comparison to experimental data
- asses sensitivity to EoS