Improved Intranuclear Cascade Models for the Codes CEM2k and LAQGSM

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During the last years, we have developed at LANL an improved version of the Cascade-Exciton Model (CEM) of nuclear reactions realized in the code CEM2k and the Los Alamos version of the Quark-Gluon String Model (LAQGSM) to describe reactions induced both by particles and nuclei at energies up to hundreds of GeV/nucleon for a number of applications. We have tested and benchmarked the CEM2k and LAQGSM codes against a large variety of experimental data on particle-particle, particle-nucleus, and nucleus-nucleus reactions and have compared their results with predictions by other currently available models and codes. Our comparisons show that the CEM2k and LAQGSM codes have predictive powers comparable to other currently used codes and describe many reactions better than other codes; therefore both our codes can be used as reliable event-generators in transport codes for applications. The CEM2k code was incorporated two years ago into MCNPX, while both CEM2k and LAQGSM are currently being incorporated into the transport codes MARS and LAHET, and we plan to incorporate both our codes into MCNP5 and LAQGSM into MCNPX in the near future.

This does not mean that our codes are perfect and without problems. Here, we present some improvements to the intranuclear cascade models of CEM2k and LAQGSM we performed recently with a primary aim to better describe the physics of nuclear reactions striving meanwhile to get also a better agreement with available experimental data. First, we have incorporated the photonuclear mode from CEM2k into LAQGSM to extend its applicability to photonuclear reactions not previously modeled in LAQGSM. Next, we developed new approximations to describe more accurately experimental elementary energy and angular distributions of secondary particles from hadron-hadron and photon-hadron interactions using available data and approximations published by other authors. Then, we studied and refined the treatments of the Pauli principle, refraction and reflection from the nuclear potential, details of the nuclear density and the momentum distribution of intranuclear nucleons. Finally, to consider reactions involving very highly excited nuclei ($E^* > 3$ MeV/A), we have incorporated into CEM2k and LAQGSM the Statistical Multifragmentation Model (SMM), as a possible reaction mechanism occurring after the preequilibrium stage. Illustrative results will be presented, unsolved problems will be discussed, and further necessary work will be outlined.

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