DSMC simulations of polarized atomic beam sources including magnetic fields

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In recent decades a lot of work has been done to understand and optimize the output of polarized atomic beam sources mainly with tracking calculations of atoms moving through the field of the sextupole magnet system with the measured parameters of the supersonic atomic beam as starting conditions. Besides of these simple calculations attemps were made to achieve an analytical description of the processes in an atomic beam source [1]. However, there are many effects which prevent a complete analytic description of the system. A new DSMC (Direct Simulation Monte Carlo) simulation based on OpenFOAM 1.7.1 using Birds [2] algorithm has been developed which calculates the output intensity including all major processes occuring in the atomic beam source, e.g., influence of magnetic fields, high frequency transitions, rest gas scattering, recombination, intra-beam scattering, and spin exchange collisions.
So far, the simulated particles have been given spin and a generic utility to include arbitrary magnetic fields has been created. The equation of motion in every timestep is solved by a fourth order Runge-Kutta scheme. Additionally, high frequency transition units are included as well as recombination on the walls and spin exchange collisions. Additionally, a generic interface for optimization algorithms was built and Adaptive Simulated Annealing (formerly Very Fast Simulated Re-Annealing [3]) was put into this framework to optimize the output of DSMC simulations. Last but not least, a tool to measure the collision age of particles in a storage cell has been created and first tests of the program are promising.
This development is in particular important for the PAX project (Polarized Antiproton eXperiments [4]) since a high-density highly polarized target is necessary in order to polarize a stored antiproton beam.

References

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