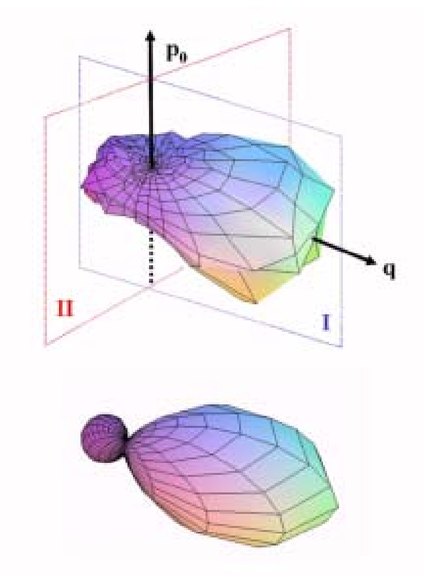
More Than Two Bodies Is Too Many

One of the most persistent problems in Physics is the description of three or more mutually interacting particles. When two objects exert a known force upon each other, for example the earth and the sun through gravity, in general their motion can be predicted with certainty. However, if a third object is added, say Jupiter, the problem can only be approached by simulations. This so-called three- or few-body problem has been giving physicists a hard time for centuries.

At the times of Newton and Galilei, researchers observed the motion of celestial bodies to solve the few-body problem. **Michael Schulz** of UMR and his collaborators at the Max-Planck-Institut für Kernphysik in Heidelberg, Germany, now performed detailed experiments to study the interactions occurring in atomic systems. Here, an additional complication in understanding the few-body problem is the wave nature of particles of atomic size predicted by quantum-mechanics.

Energetic bare carbon ions were made to collide with neutral helium atoms so that electrons were knocked out (ionized). The scientists then recorded complete three-dimensional (3-D) images of the spatial distribution of the emitted electrons, an example is shown in the figure below. The experimental data were compared to state-of-the-art calculations (bottom part of the figure) performed by the group of **Don Madison**, also of UMR.



Fully differential electron distribution from C^{6+} + He collisions

Previous studies were restricted to electrons emitted into one specific plane called the scattering plane (the one spanned by the arrows labeled q and p_o in the figure). For this plane, theory and experiment are consistently in very good agreement. This success gave rise to the hope that such ionization processes can be satisfactorily modeled. However, the now-published 3-D images reveal serious and qualitative discrepancies outside the scattering plane. These differences were unexpected and they clearly indicate that the experimental results have revealed some physical effects that have not been previously seen or predicted by any published theory. These results appeared in *Nature* **422**, p. 48 (March 6, 2003).

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