

## 4 Conclusion

In this study, we measured the scattering differential cross sections of collisions of noble gas atoms with a carbon in  $C_{60}$  and in  $CH_4$ . The experimental results for  $CH_4$  are well accounted for by the Molière potential, so the accuracy of the present experiments was thereby confirmed. On the other hand, the results of a Molecular Dynamics simulation using the Molière potential showed that the multi-scattering collisions of atoms in the  $C_{60}$  are negligible for large angle scattering. These results showed that the interatomic potential of atomic collisions with  $C_{60}$  is different from the binary Molière potential. We deduced a new interatomic potential with an additional screening function  $S(r)$ , experimentally. The new interatomic potential reveals a new interaction mechanism in atom-cluster interactions, which is closely correlated with the geometrical symmetry of the  $C_{60}$  and should be considered a collective effect, i.e., a non-trivial many body interaction.

We extracted the electron density distribution of the reduced atom with atomic number  $Z_{eff}$ , from the new interatomic potential using Poisson's equation, and compared it with the Molière potential. The results of this analysis made clear that, in the case of atomic collision with the  $C_{60}$ , the electron density distribution between the colliding atoms doesn't change at small interatomic distances or, of course, at far distances; however, it changes drastically at middle distances, distances near the overall width,  $a_2$ , of the new additional screening function  $S(r)$  (see Figure 44). Therefore the electron density distribution as the noble gas atom is breaking into the  $C_{60}$  and while it is temporarily embedded in the  $C_{60}$  should determine the additional screening effects.

It is highly probable that the 60  $\pi$  electrons play an important role. These many body effects underline the need to develop a more thorough theoretical understanding of collision mechanisms in many body systems. The electron density distribution for a given set of initial condition could perhaps be calculated using approximations such as the Local Density Approximation or the *ab initio* methods.

Furthermore, when the additional screening functions were “scaled” by the binary atomic potential, the Molière potential, they were found to be independent of the atomic number of the noble gas atoms. This is very interesting and seems to indicate some unknown physical mechanisms are at play. This is an open problem now.

This study should influence atomic collision simulations in a solid. Not only many body collisions at the same time must be considered, but also the interatomic potential must be corrected if the extra screening effect depends on a crystal structure. Especially in the case of Xe, the difference in the total collision cross sections between the free atom situation and the crystal is not negligible. Therefore, the correct potential should be used in the computer simulations.

In conclusion, we hope these results will foster a new area of exciting and fruitful research.