§ 7. The Role of Potential Saddle in Ionization of Hydrogen Atoms by Slow Protons

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The saddle point (SP) mechanism for single ionization by ion impact has attracted much attention because of its potential to provide an universal explanation for electron ejection in low energy ion-atom collisions. The SP mechanism states that the ejected electron should stay around the internuclear potential saddle and move with the saddle velocity in the lab frame of reference. In this regard, the SP mechanism for ion impact seems to be well-defined, easily a verifiable concept. But after its introduction in the early 80s, this mechanism has been the center of much controversy [1].

In order to shed further light on the importance of the SP mechanism, full three-dimensional ejected electron distributions for proton impact ionization of atomic hydrogen are calculated for impact energies from 0.1 to 10 keV/amu. The theoretical approach used here is the molecular orbital close-coupling method which has been successfully applied to study ionization processes in low-energy ion-atom collisions [2].

We find that the ionization probability of u (*ungerade*) electrons are about one order of magnitude greater than that of g (*gerade*) electrons at energies stated above. The ejected electron distributions at impact energy $E = 5$ keV/amu are drawn in Figs. 1 and 2 for the g and u components, respectively. It is found that i) the g electrons do stand on the potential saddle point and are promoted to continuum with the saddle being pushed upward; ii) but the much easily ionized u electrons tend to stay far away from the saddle. Since the $H^+ + H$ impact ionization are dominated by the ejection of u electrons, they can not balance themselves well on the potential saddle because the u symmetry wavefunctions have a node right on there. Hence, it appears that the SP mechanism is not important ionization mechanism, at least, at low keV energies.

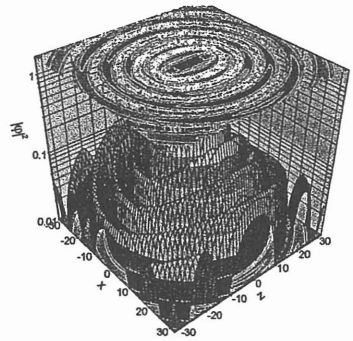

Fig. 1. Ejected electron distribution of g component resulting from a $p-\mathrm{H}$ collision at $E = 5$ keV/amu. The two protons are located at (0,-8) and (0,8) respectively.

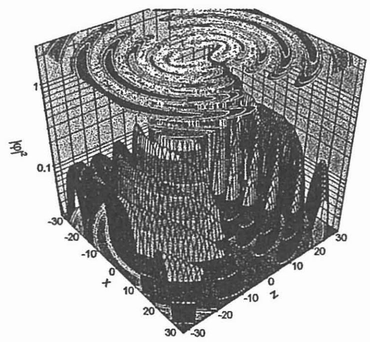

Fig. 2. Same as Fig. 1, except for *ungerade* component

References

[1] N. Stolterfoht, R. D. DuBois and R. D. Rivarola, *Electron Emission in Heavy Ion-Atom Collisions*, Berlin: Springer, (1997)

[2] S. Zou, L. Pichl, M. Kimura and T. Kato, Phys. Rev. A. **66** 042707(2002).