DYNAMICS DAYS SOUTH AMERICA 2010
International Conference on Chaos and Nonlinear Dynamics

INPE – National Institute for Space Research
São José dos Campos – SP – Brazil – July 26-30, 2010

INTENSE–LASER DOUBLE IONIZATION: INSIGHTS FROM NONLINEAR DYNAMICS

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keywords: Chaos in Hamiltonian Systems.

One of the most striking surprises of recent years in laser-matter interactions has come from multiple ionization by intense short laser pulses. Multiple ionization of atoms and molecules is usually treated as a rapid sequence of uncorrelated events. However, in the early 90's, experiments using intense laser pulses found *correlated* double ionization yields could exceed uncorrelated ones by several orders of magnitude. The precise mechanism that makes electron-electron correlation so effective follows the "recollision" scenario: An ionized electron, after picking up energy from the field, is hurled back at the ion core upon reversal of the field and dislodges the second electron.

It turns out that entirely classical interactions are adequate to generate the strong two-electron correlation needed for correlated double ionization. In this talk, I will revisit the recollision mechanism using a nonlinear dynamics perspective. I will show that this recollision scenario has to be complemented by the dynamical picture of the inner electron [1, 2]. Using this global picture of the dynamics, we were able to derive verifiable predictions on the characteristic features of the "nonsequential" process [1–3].

The recollision scenario which works so well in linearly polarized (LP) fields is much more difficult to justify in fields in which the ionized electrons tend to spiral out from the core and to miss it like cicurlarly (CP) or elliptically polarized fields. In some experiments using CP fields, the double ionization yields follow the sequential mechanism, confirming current thinking, whereas in others these yields are clearly several orders of magnitude higher than expected, in apparent contradiction with it. The question we have recently resolved is [4]: Are recollisions possible in pure CP fields or does one have to rely on a small residual ellipticity? We explain these seemingly contradictory findings using a classical Hamiltonian model. In addition, we show that, contrary to common belief, recollision can be the dominant mechanism leading to enhanced double ionization yields in CP fields.

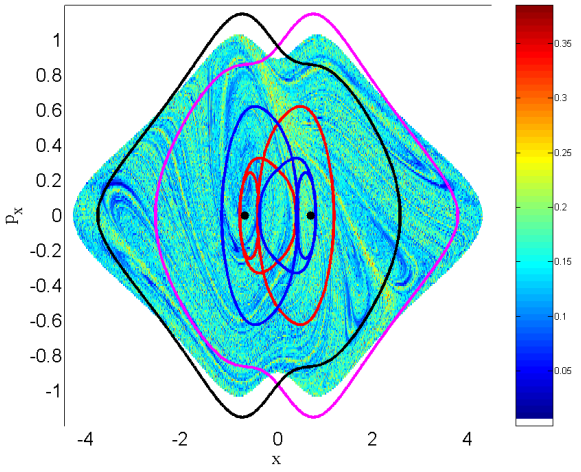

Figure 1 – Finite time Lyapunov map for H_2 [2]. Initial positions are chosen on the surface (x, p_x), $y = 0$ and $p_y(\geq 0)$ adapted to be on the ground state energy surface. We also display projections in the plane (x, p_x) of four organizing periodic orbits for the model.

References

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