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Electron capture by low velocity highly charged ions A tribute to Michel Barat

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Synopsis Michel Barat passed away last November at the age of 80. We briefly review the contributions under his supervision where we revisited atomic collisions in the blooming context of highly charged ions.

One of us started his PHD by constructing the setup that Michel had imagined. A 2D position sensitive detector in the focal plane of an electrostatic analyser [1]. Such detector was not available but taking a proposal from D. de Bruijn, FOM Amsterdam, we built it and were able to record, at once, the energy and angular scattering profile in coincidence with recoil ions and emitted photons (UV and Xrays). We were ready to do physics with these weird ions *e.g.* O^{8+} . **In what sense is the captured electron rotating?** With NO Andersen we could show that the captured electron tends to rotate along the intuitive direction [2]; A runner trying to jump into a merry go round will find which way to go. However this should not hold in the molecular regime where the electron motion is much faster than that of the nuclei. V. N. Ostrovsky designed an elegant text-book quasi-molecular interpretation, that we calculated with A. Dubois *et al.* **Why do we observe higher n value?** The selective electron capture into a given n shell was well explained by the coulombic barrier model but evidence for higher n capture were reported. Michel could interpret the population of higher n values by transitions at inner crossings [3] predicted by the Barat-Lichten-Fano electron promotion model. **Are the electrons captured simultaneously or one after the other?** We observed both situations [4] and we reformulated the question differently. What is the driving mechanism in simultaneous double electron capture? With V Sidis, we showed that double electron capture can be explained [5] by a second order effect without the need of di-electronic interaction. The same mechanism was found responsible for other two electron process such as Transfer-Excitation. **How do two highly excited electrons manage to avoid autoionisation?** The

data indicated an initial population of quasi symmetric doubly excited states *e.g.* $O^{6+}(4l,4l')$ [6] way above several ionisation limits and predicted to be auto-ionising. We showed that a significant part of the $(4l,4l')$ population transfers to the straddling *Rydberg* by di-electronic interaction and calculate the effect with H. Bachau.



Figure . Michel Barat played a key role to promote the physics of atomic and molecular collisions.

With A. K. Kazansky [7] we showed that the electric field of the receding target transforms these linear Rydberg into circular Rydberg states where both electron orbits do not overlap anymore. With S. Martin we identified the population of long-lived triply-excited double Rydberg. In less than ten years Michel *et al* published more than 40 papers, always with great enthusiasm. Upon turning towards atomic collisions at surfaces we of course started by constructing an ambitious 2π multi coincidence setup [8].

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