Time-Dependent Hartree-Fock for nuclear reactions

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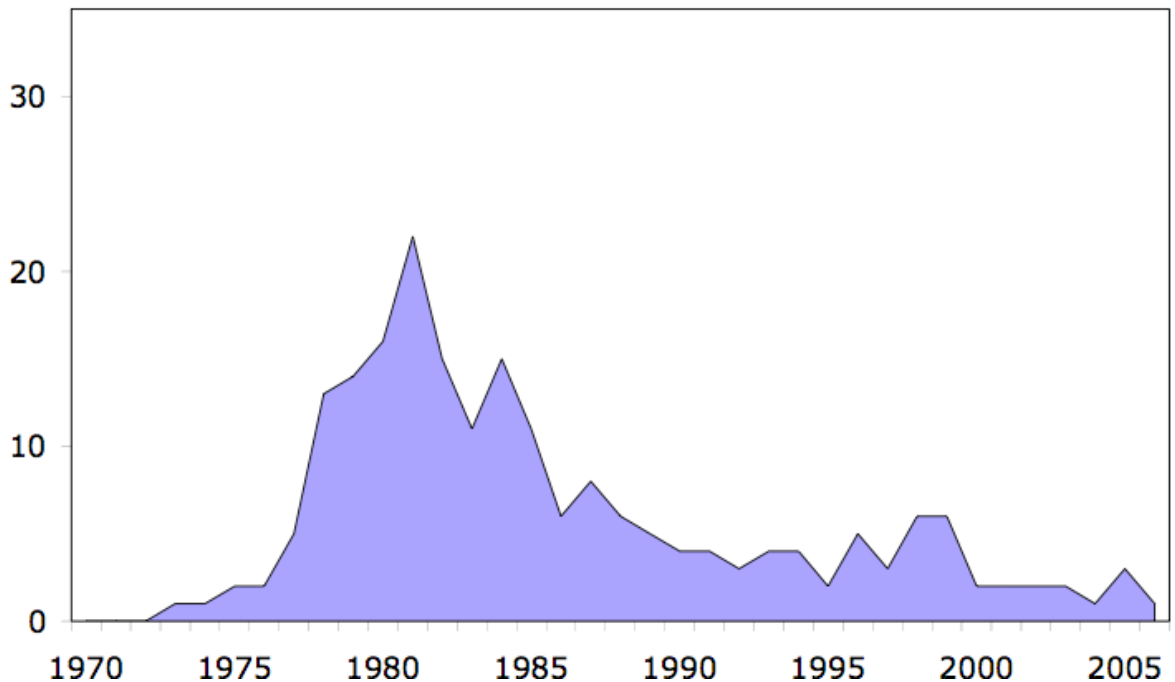
TDHF, *back to the future…*

P.A.M. Dirac, Proc. Cam. Phil. **26**, 376 (1930)



TDHF publications
(nuclear physics)

Why a TDHF come back ?

Exotic nuclei *(SPIRAL 2)*

- **fully microscopic**
  $\Rightarrow$ ***predictive where nothing is known***

- **same treatment for the structure and the dynamics**
  $\Rightarrow$ ***interplay structure-mechanisms***

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TDHF3D

- **P. Bonche's code**
  K.-H. Kim, T. Otsuka and P. Bonche, JPG **23**, 1267 (1997)

- **full Skyrme force including spin-orbit**

Examples of recent TDHF *(and beyond)* studies

Charge equilibration in fusion

- preequilibrium Giant Dipole Resonance *(GDR)*
- way to fusion

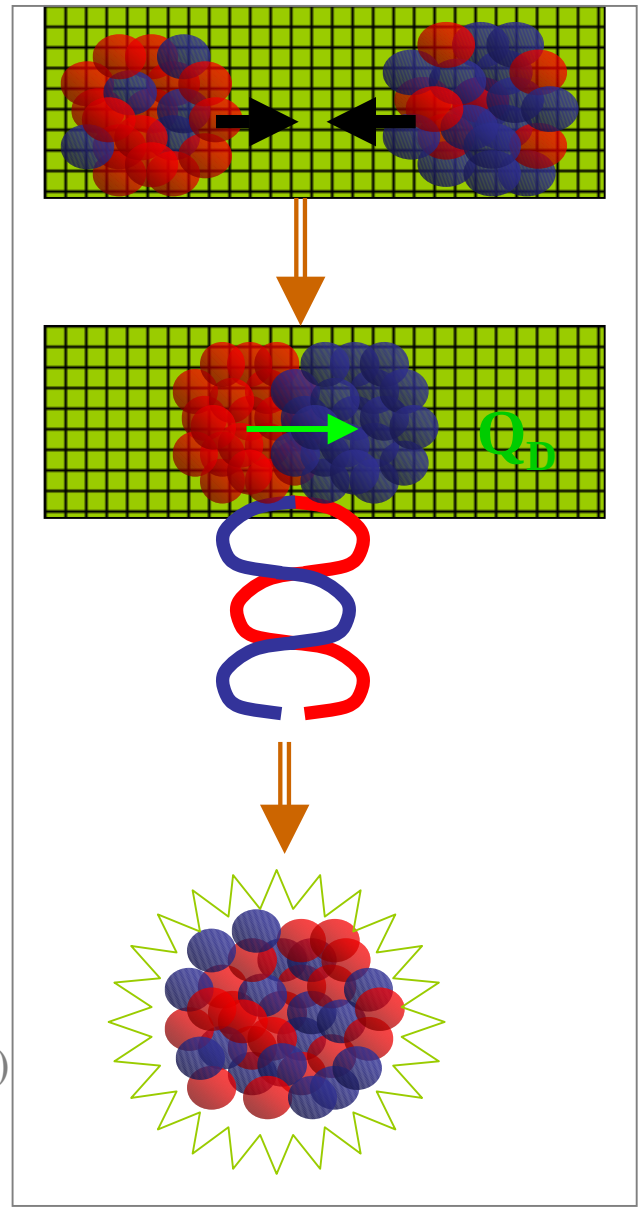
Coulomb excitation

rotational states

I) Charge equilibration in fusion

The idea

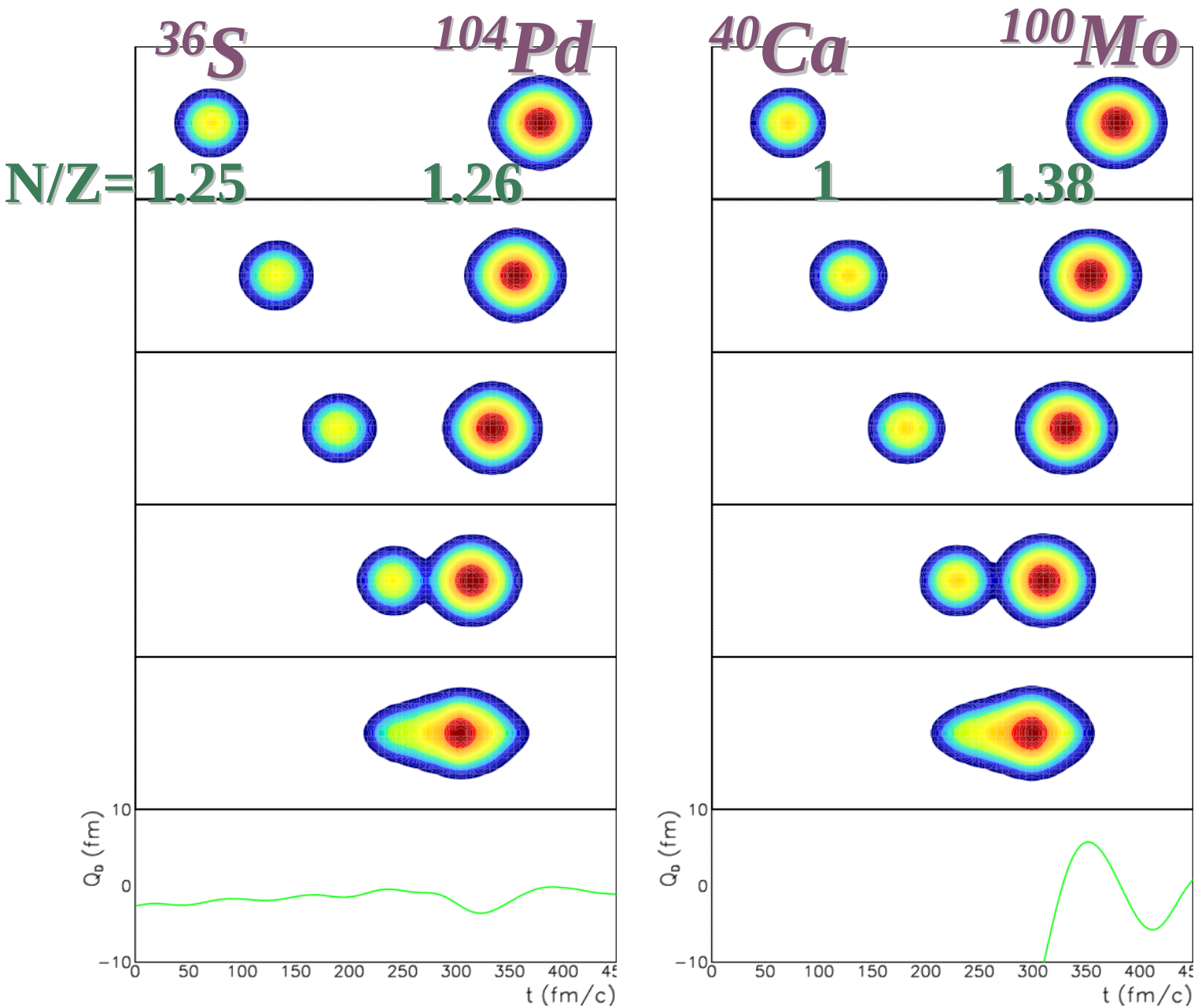
- N/Z assymetric reaction
- dipole moment at contact
  $Q_D \propto |R_{protons} - R_{neutrons}|$
- oscillation of Q_D (GDR)
  during « *preequilibrium* »
- characteristics of $Q_D(t)$
  $\Rightarrow$ way to fusion



P. Bonche and N. Ngô, PLB **105**, 17 (1981)
E. Suraud, M. Pi and P. Schuck, NPA **492**, 204 (1989)
Ph. Chomaz, M. Di Toro and A. Smerzi, NPA **563**, 509 (1993)
C. Simenel, P. Chomaz and G. de France, PRL **86**, 2971 (2001)
V. Baran, D.M. Brink, M. Colonna and M. Di Toro,
PRL **87**, 182501 (2001)

I) Charge equilibration in fusion

TDHF

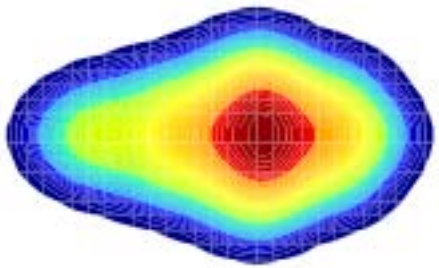


I) Charge equilibration in fusion

TDHF *Vs* Experiment

- **evolution of the density**

  ⇒ **prolate deformation**

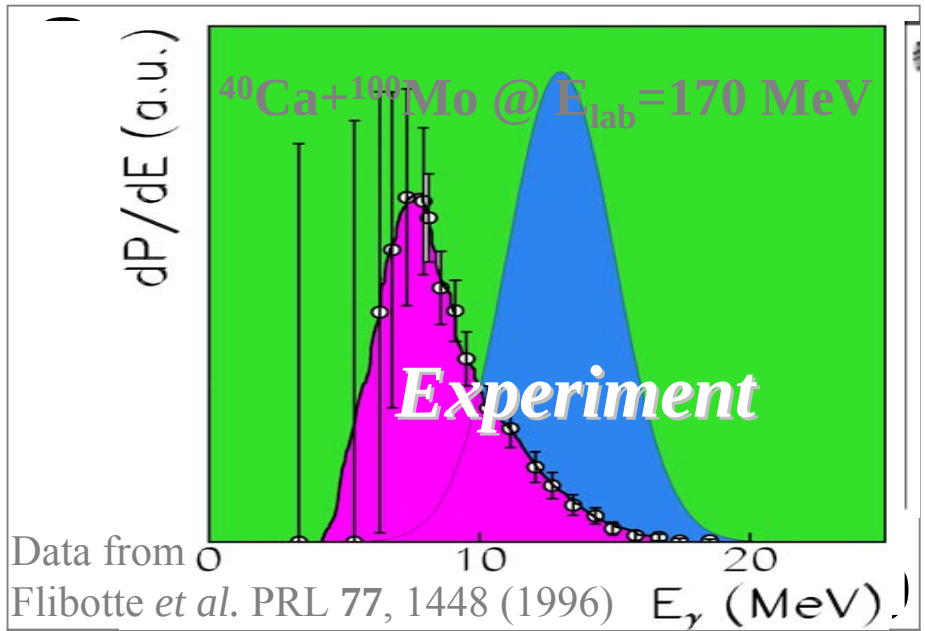


- **γ-spectra ≡ Fourier of charge acceleration**

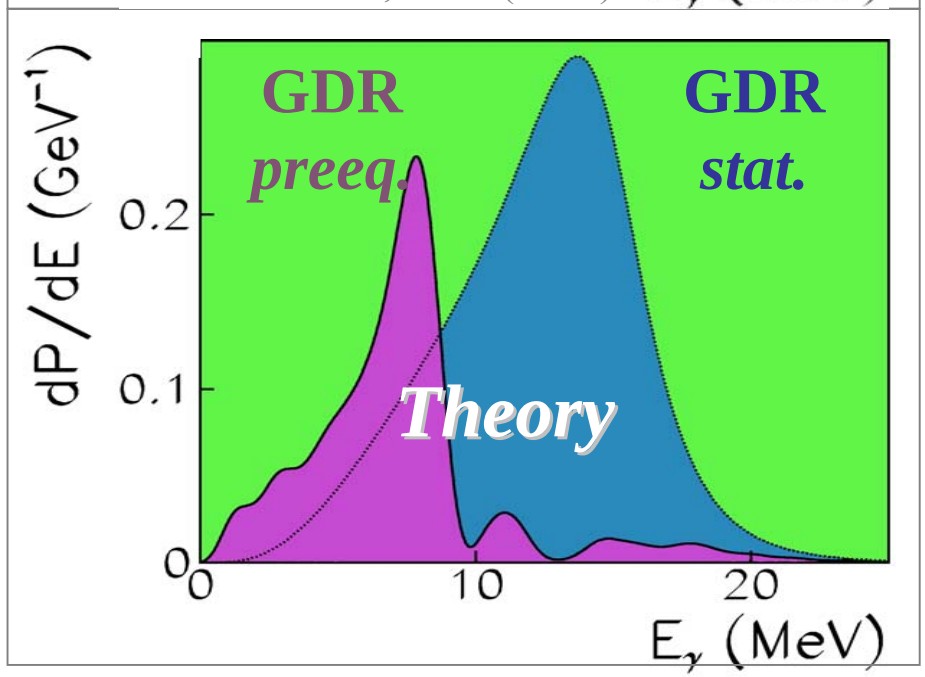
  (Jackson, *Classical Electodynamics*, Wiley NY 1962)

⇒ $E_{GDR}^{preeq.} < E_{GDR}^{stat.}$

$$E_{GDR}^{preeq.} = E_{GDR}^{stat.}(1-\varepsilon)^2$$



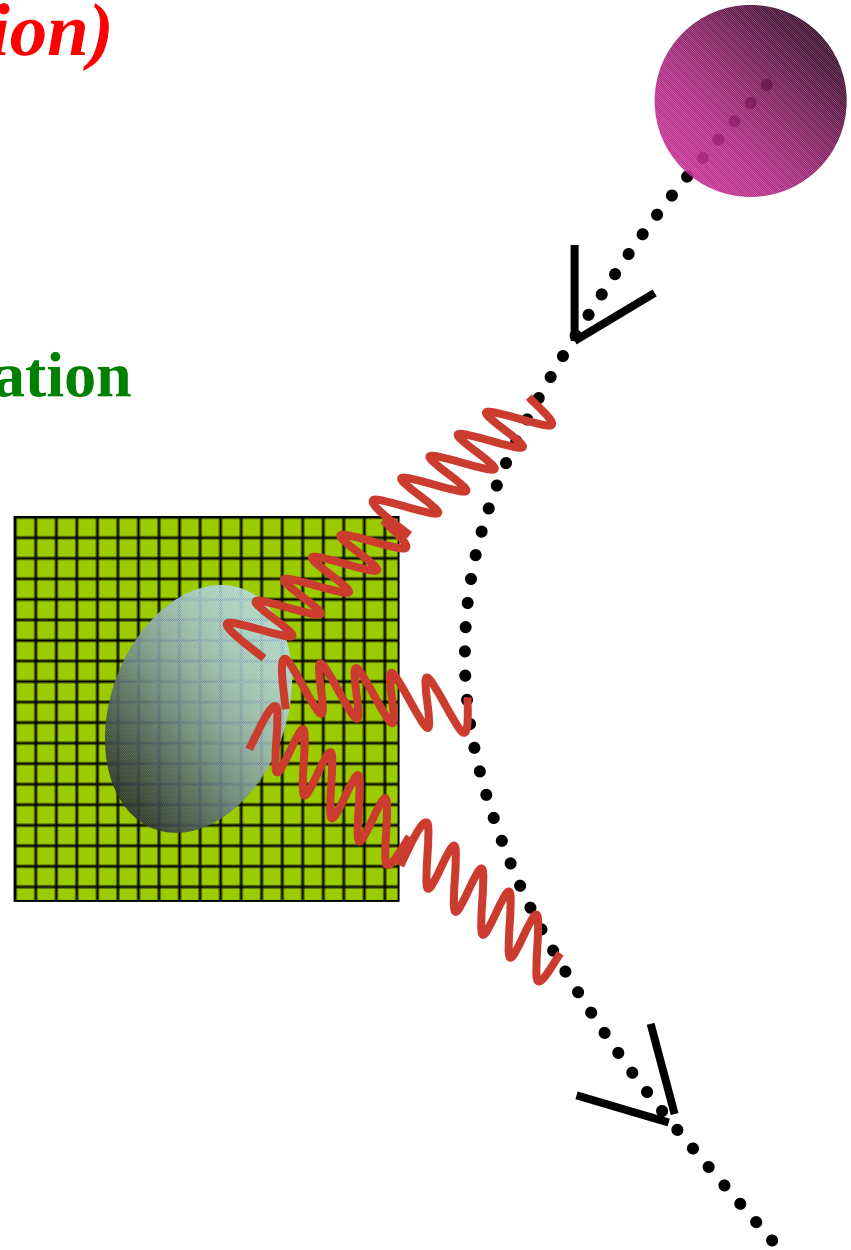
Data from Flibotte *et al.* PRL **77**, 1448 (1996)



II) Coulomb excitation *(rotation)*

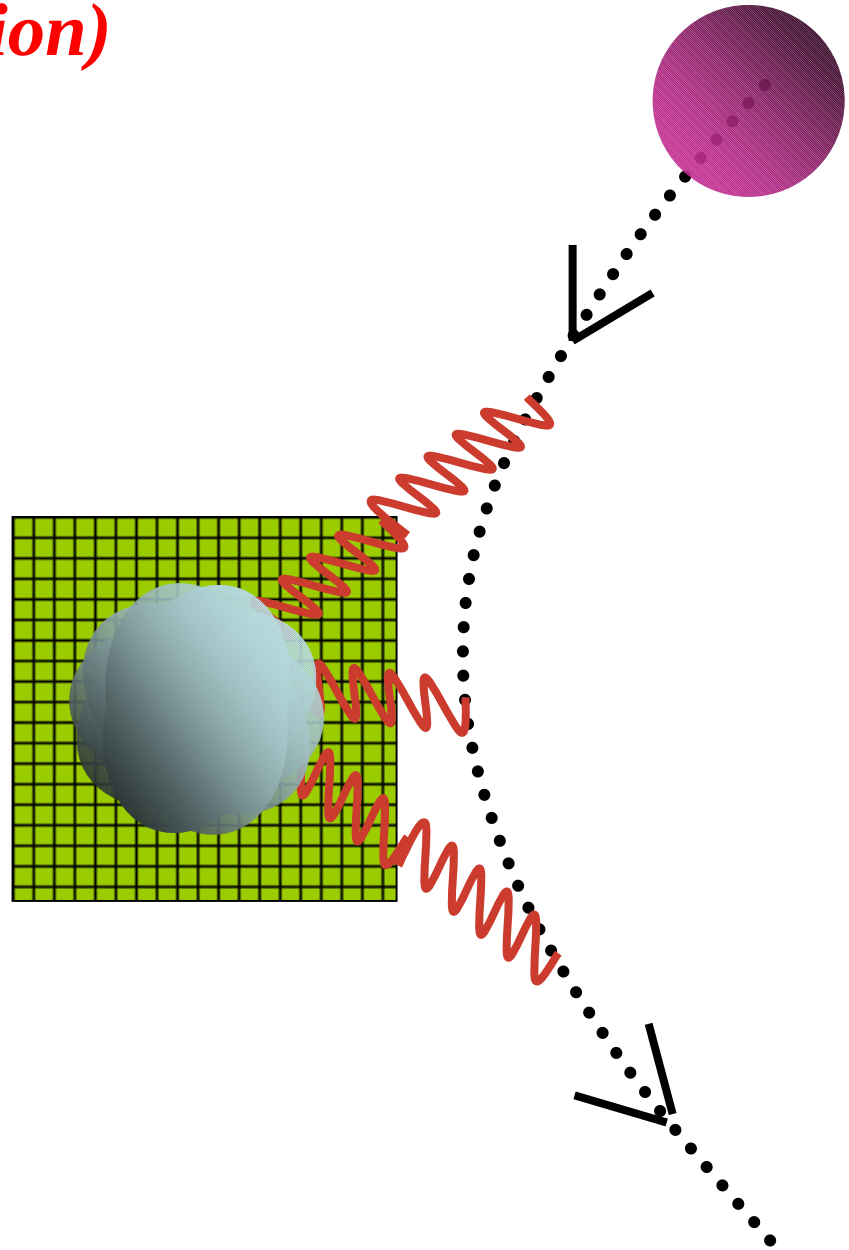
Long range Coulomb excitation

$$\hat{V}_{ext}(t) \propto \frac{Z}{\left|\mathbf{R}_{Ruth}(t) + \hat{\mathbf{r}}\right|}$$



II) Coulomb excitation *(rotation)*

Many initial conditions
(≠ orientations)

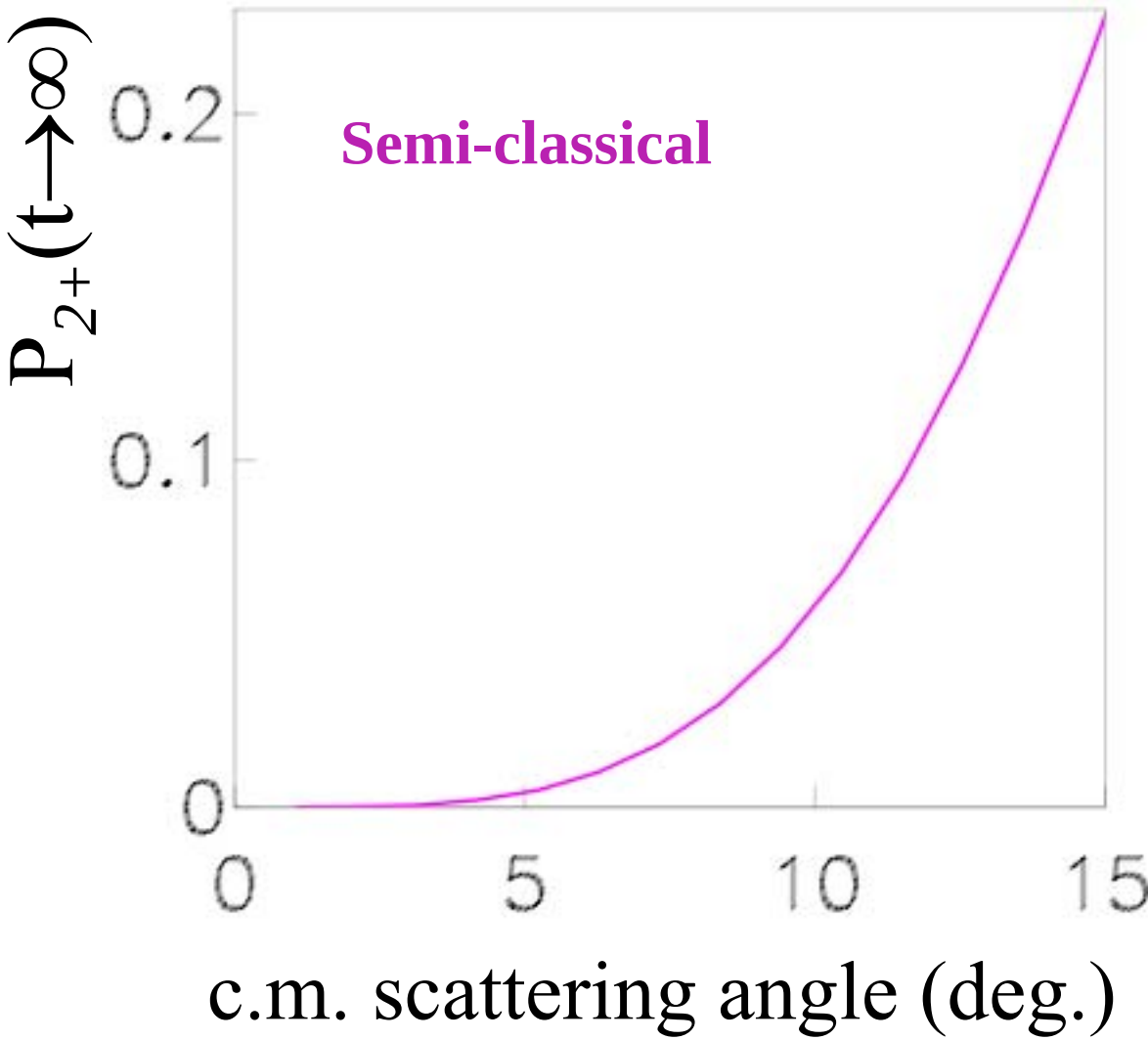


II) Coulomb excitation *(rotation)*

Excitation of the first 2^+

- ^{24}Mg (+ ^{208}Pb)

- E_{CM}=690 MeV



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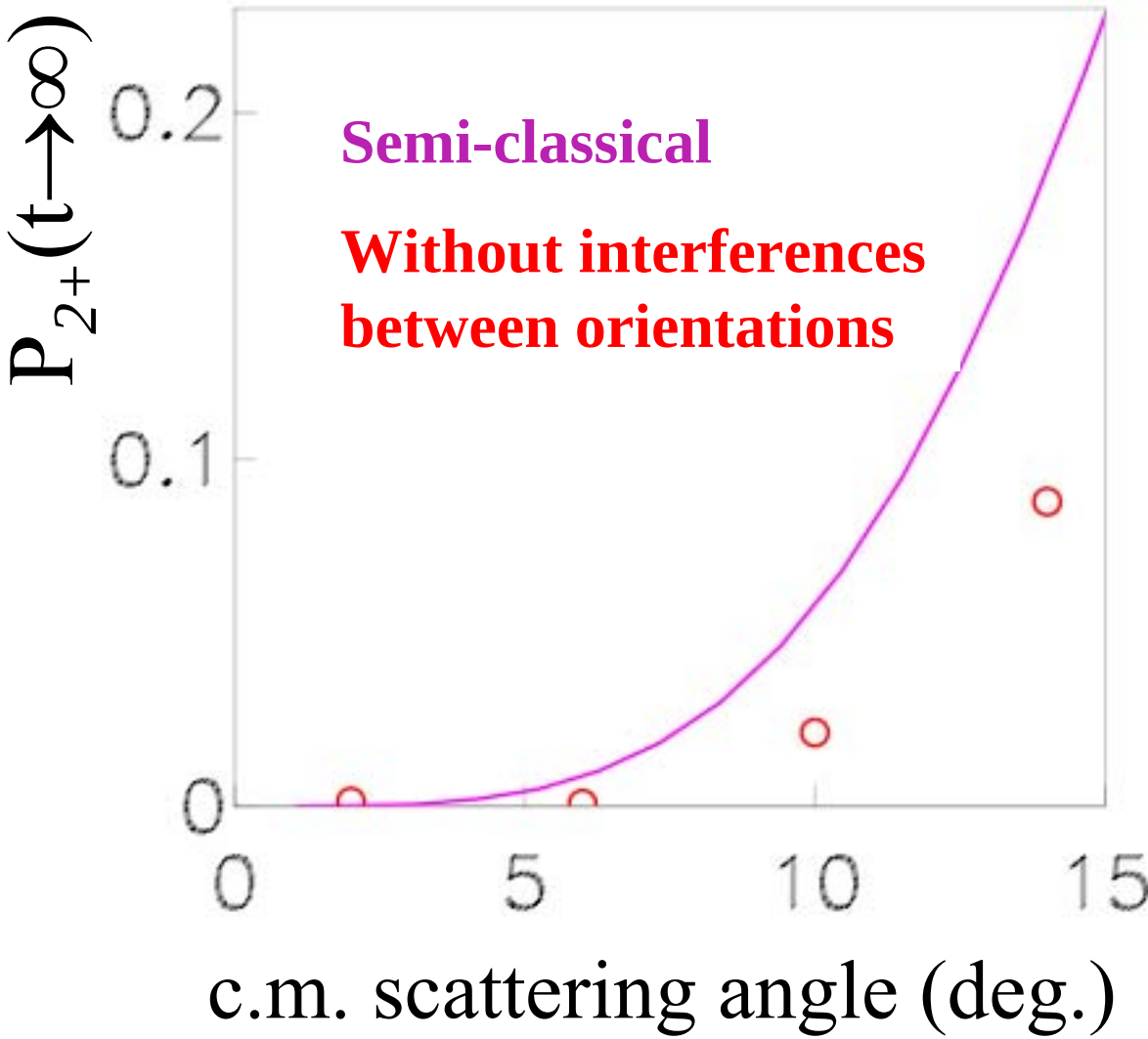

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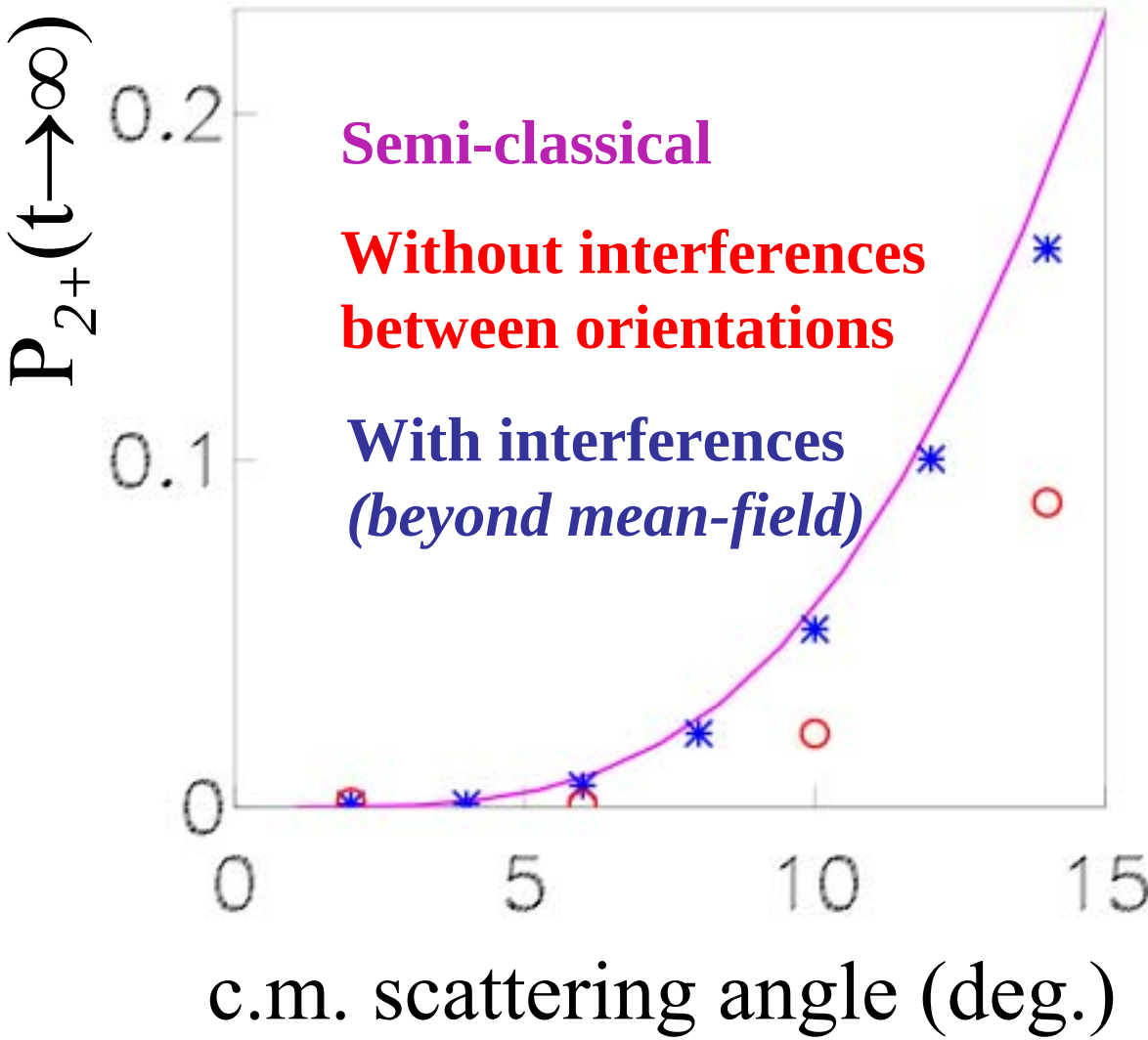

Conclusions

interplay structure / reaction mechanism

charge equilibration in fusion

predictive power

Coulomb excitation *(rotation)*

Perspectives

pairing *(TDHFB)*

beyond Mean Field *(TDGCM)*

TDHF, *back to the future…*

TDHF publications
(nuclear physics)