

Laboratory for electron –atom collisions,  
IP Belgrade and early collaboration with  
the LPOC, Université Paris VI in  
seventies.

Iztok Čadež  
13. October 2017

Colloquium in honor of Valerij Bočvarski, Belgrade  
13.-14. October 2017

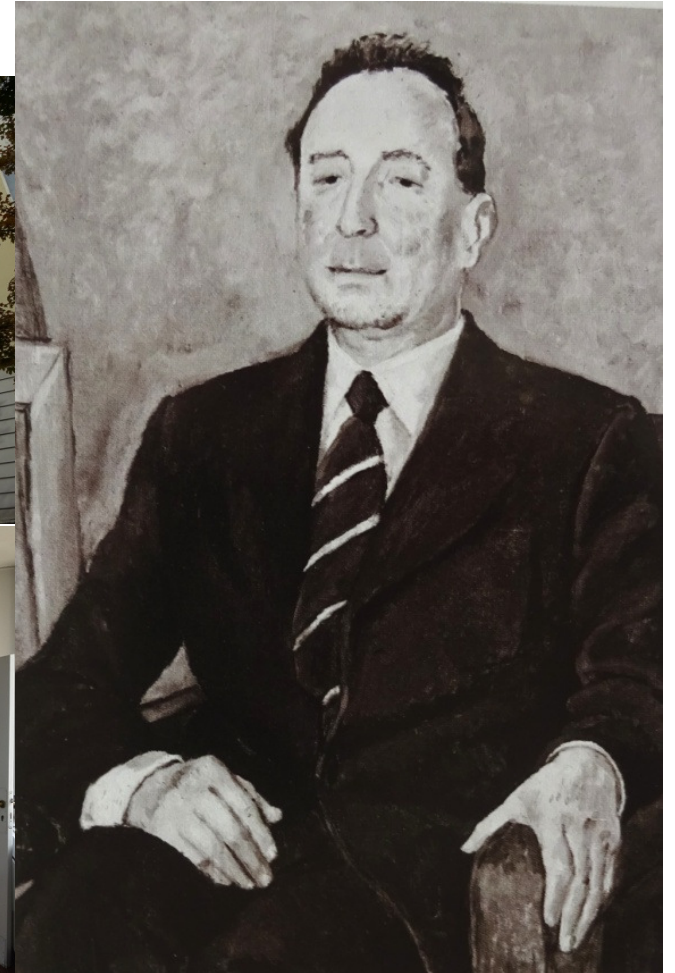
Short overview is presented of the atmosphere and activities in the laboratory for electron-atom collisions at the Institute of Physics in Belgrade (IPB) at the time when Valja joined us. Also, initial collaboration with former Laboratoire de Physique et Optique Corpusculaires (LPOC) at Université de Paris VI in early seventies is described. There I first met professor Jean Reinhardt with whom Valja collaborated later and eventually developed deep friendship.

- few words on the laboratory for electron – atom collisions at IP Belgrade in seventies
- my early experience in collaboration with LPOC, Paris
- building experiments
- some remarks on the science development and evaluation

Beograd

Institute of Physics

Main location of the Institute of Physics was in early seventies on the 4<sup>th</sup> and 5<sup>th</sup> flour of C-wing of PMF at Studentski trg in downtown Belgrade



**Professor Aleksandar Milojevic  
(1912-1986)  
Founder and first director of IFB  
(1961-1978)**

Wisdom of professor Aleksandar Milojević (1912 – 1986), founder of the Institute of Physics laid sound principles for young scientific organization established in 1961.

- Timely setting modern fields of research – e.g. light sources; lasers; 1977-1978 IPB reorganization.
- Choosing dedicated young collaborators and sending them to outstanding laboratories to become later the leaders of new laboratories.
- Promoting full freedom of research to new laboratories.
- Employing excellent technical staff from Vinča Institute.
- Providing scholarships for physics students at final years and employing them afterwards as full time researchers.



Initially IPB was mainly a platform to coordinating research of physics professors at different faculties of The University of Belgrade. **Dr. Vladeta Urošević**, deputy director during A. Milojević's directorship, was a key organizer of the mature Institute as research organization with full-time researchers.

# Laboratory for electron-atom collisions



**Milan Kurepa (1933-2000)**, founder of the Laboratory for electron-atom collisions at IPB. The study of atomic collisions in Belgrade started after his return from postgraduate visit in the laboratory of professor **J. D. Craggs** at the University of Liverpool in 1963. **Vladeta Urošević**, electron impact photo-excitation was also member of this laboratory.

Soon after also started active theoretical work initiated by **Ratko Janev** (moved to IPB from IBK Vinča) after his return from Ph.D. stay in Leningrad (StPetersburg) and **Petar Grujić** after his return from Ph.D. stay at UC, London.

The same time **Branka Čobić** established and headed laboratory for **heavy-particle collisions** at IBK, Nuclear Institute in Vinča.

# Laboratory for electron-atom collisions

Wisdom of Milan Kurepa, founder of the Laboratory

- Sending young students to outstanding laboratories abroad
- Stimulating full freedom of research to new colleagues
- Timely acquiring the most recent literature and modern experimental equipment
- Organizing regular seminars, conferences and publishing – active synergy
- Promoting cosmopolitan atmosphere

From the very beginning the Laboratory was very vivid and innovative environment. Valja started his contacts and collaboration with laboratory in late seventies.





# Members of the group

I joined group in fall 1968

From Valja's CV:

1976 Bc.Sci. at Dep. of Physics, Belgrade

1979 Ms.Sci. at Dep. of Physics, Belgrade

1986 Ph.D. at Dep. of Physics, Belgrade



# Building the instruments - electron-A/M collisions -

Early times

ZAGA (attachment in gases) - M. Kurepa, E. Danilović, I. Čadež, A. Stamatović, V. Pejčev, D. Belić

DIFRA (differential scattering) - L. Vušković, M. Kurepa, S. Cvejanović

POBA (excitation of A/M) - V. Urošević, M. Rodić, J. Kurepa, M. Tasić

MS (quadrupole mass spectroscopy) A. Stamatović, J. Jureta, N. Đurić

# Building the instruments - electron-A/M collisions -

Later:

SPEPRA (threshold spectroscopy) S. Cvejanović, J. Jureta, D. Cvejanović

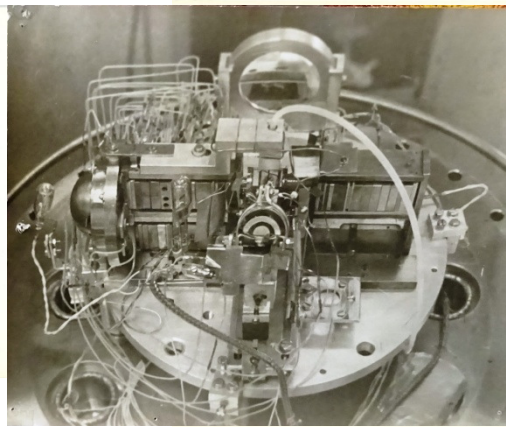
ESMA (Electron (differential) Scattering on Metal Atoms - L. Vušković, V. Pejčev, B. Marinković, D. Filipović, P. Jovanović

UGRA (angular distributions of ions) I. Čadež, D. Popović, S. Madžunkov, A. Milosavljević, P. Jovanović

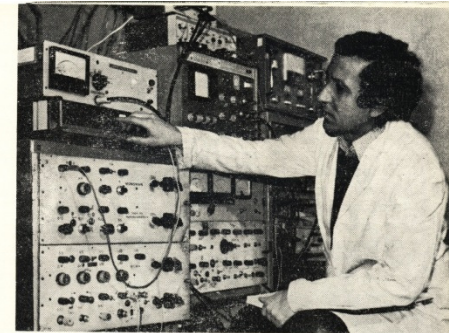


# INSTITUT ZA FIZIKU

BEOGRAD  
1981.

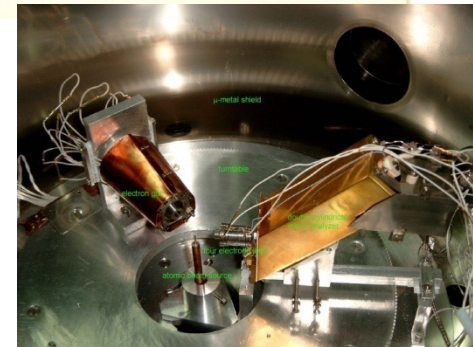
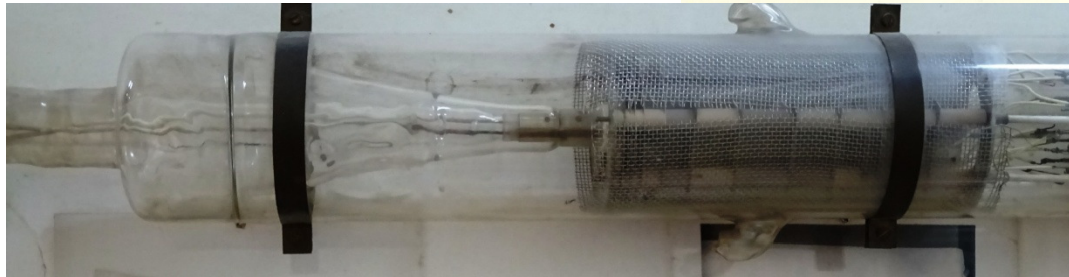


...bno karakte-  
...vačkim i na-  
...i i inostran-  
...ja saradnja  
...koji je jedan  
...jedan od čla-  
...danas većina  
...gradu bila ja  
...m tako i raz-  
...  
...tutom »Boris  
...etima u Kra-  
...i Titogradu.  
...za hemijska,  
...u Beogradu,  
...grad. Eeekt-

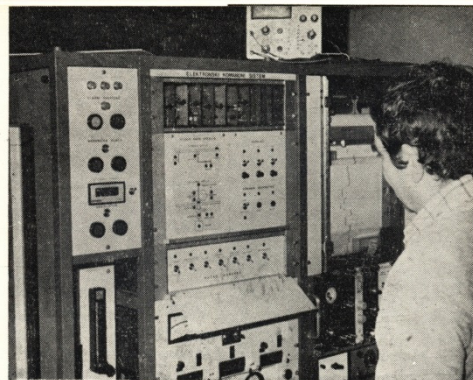


U oblasti eksperimentalnih istraživanja atomske i molekularne fizike postignuti su značajni rezultati u međunarodnim razmerama.

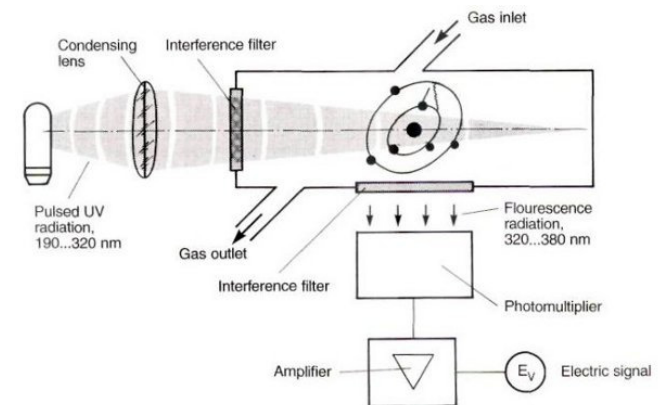
7



...vih poluprovodnič-  
...materijala, dielekt-  
...d.  
...terijala,  
...određivanje mag-  
...alima,  
...netnih defektosko-  
...nom polju kao me-  
...karakteristika čeli-  
...opija metala,  
...organskih i organ-  
...materijala,  
...a u raznim materi-



U Institutu su realizovani mnogi značajni sistemi za potrebe privrede. Sprema savremenih mernih tehnika, originalno projektovane elektronike i isto takvih mehaničkih sklopova omogućava realizaciju kompleksnih automatskih uređaja.



# Building the instruments

Stimulates creativity and originality

Enables acquiring specific new experimental

New technologies

- electron/ion optics - low energy, high resolution,
- vacuum science,
- electronics,
- new materials

(Semi)precision measurements

Has high educational potential

Promotes high-quality international collaboration

Institute of Physics is now located at wonderful site in Zemun close and above Danube river, having all conditions for further development.

Fields of research in which our laboratory was active in the past dramatically changed from the point of view of their actuality and complexness of needed equipment.

Nevertheless, by **growing together** we did acquire new knowledge and following the continuity new generation of young scientists work in modern fields of science. However, fundamental principles of scientific work do not change with time.



# Paris

Laboratoire de Physique et Optique  
corpusculaires (LPOC)

Université Paris VI – Pierre et Marie Curie

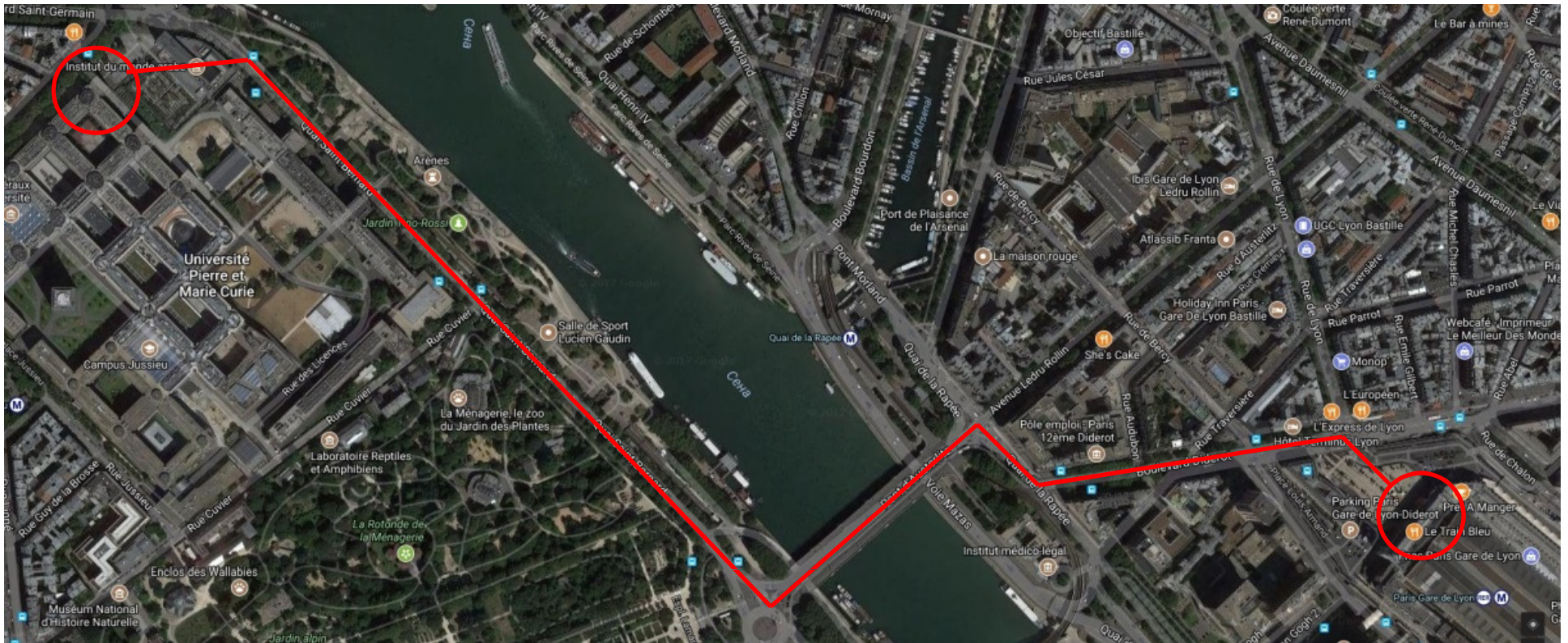
One day in the spring of 1972 dr. Vladeta Urošević came to me and asked if I am interested to go for a postgraduate visit to the laboratory of dr. Jean Reinhardt in Paris. Namely, there was one scholarship of the French government still available.

Next day, after talking with my family, I accepted this possibility although the group was not very known as compared to laboratories where other colleagues went.

The time has shown that I did right!



There are some memorable days in the life for which one remembers almost every moment of it. One such day was my day of arrival in Paris in early October 1972. From the moment I went off the Simplon express train at the Gare de Lyon, walk to 11 quai Saint-Bernard to the entrance of the laboratory in Tour 12-EV, meeting there for the first time with **Jean Reinhardt**, to the late evening at his parents home where I met his whole family all is still in my memory as being yesterday!

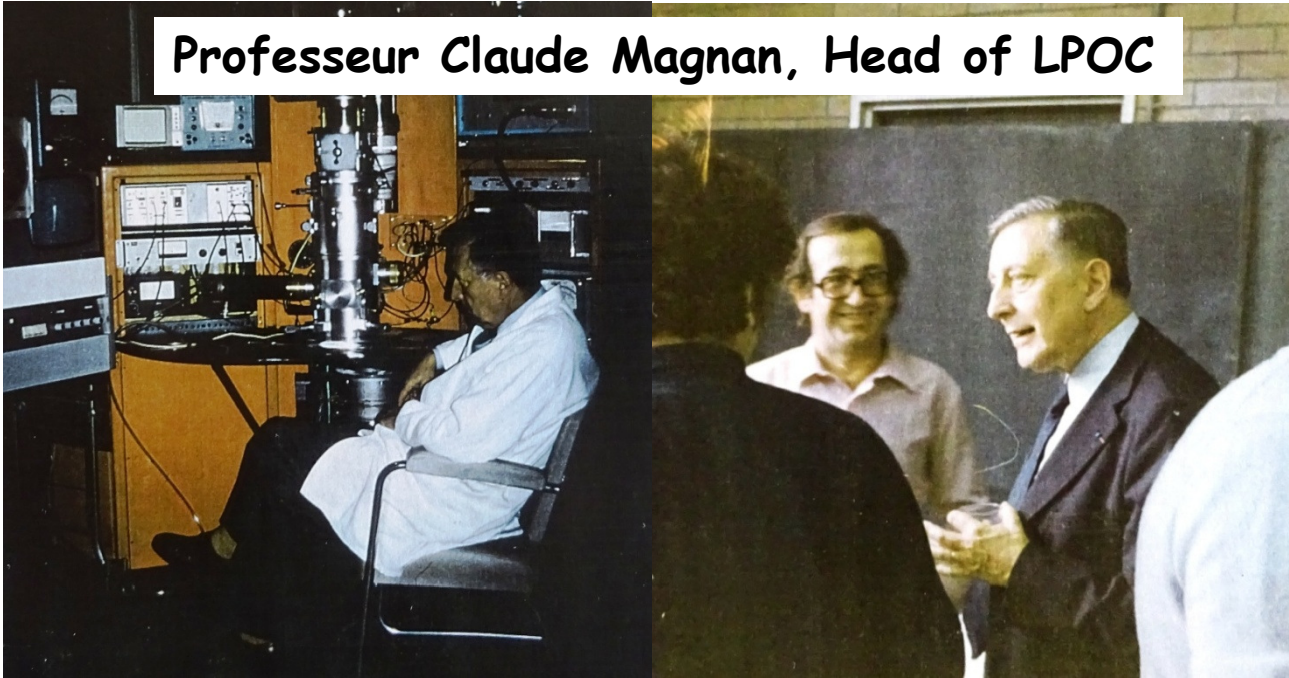


When I joined collision group at LPOC in October 1972, two researchers had PhD, Jean Reinhardt and Richard Hall (at that time at JPL, Pasadena). New electrostatic electron spectrometer was built and Jean Mazeau was finishing his PhD thesis on this instrument. Collaboration with Jean Reinhardt did not last long as he left for Université Paris Sud in fall 1973.



# Laboratoire de Physique et Optique corpusculaires (LPOC)

Professeur Claude Magnan, Head of LPOC



Two groups:

## **Atomic collisions**

Jean Reinhardt

Richard Hall

Jean Mazeau

Gerard Joyez

François Gresteau

Catherine Schermann

Françoise Pichou

Michel Landau

Jean-Pierre Grouard

Jean-Louis Montmagnon

## **Plasma physics**

(M. Skowronek, Y. Vitel –  
later close collaboration  
with Marko Popović  
from IPB)



# Université Paris - Sud

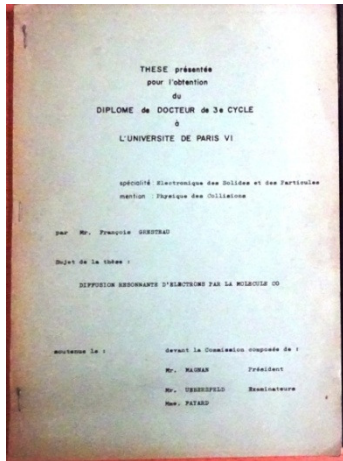


J. Reinhardt initiated my collaboration with prof. F. Fiquet-Fayard on theory of resonant electron-molecule collisions.

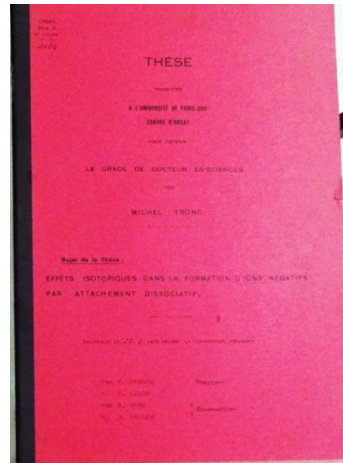


**Prof. Florance Fiquet - Fayard**

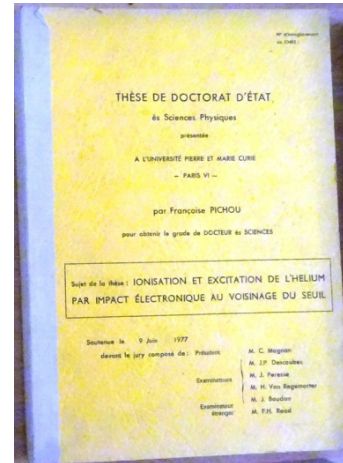
Some MSc and PhD theses of the colleagues from LPOC - seventies were very rich from the point of creativity and fast growth



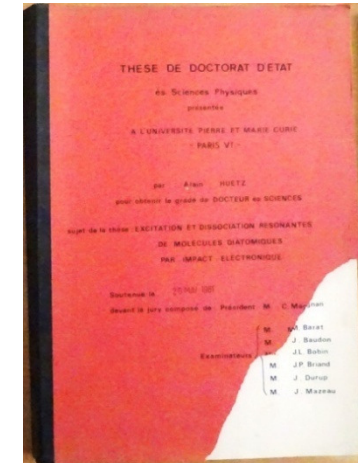
François Gresteau



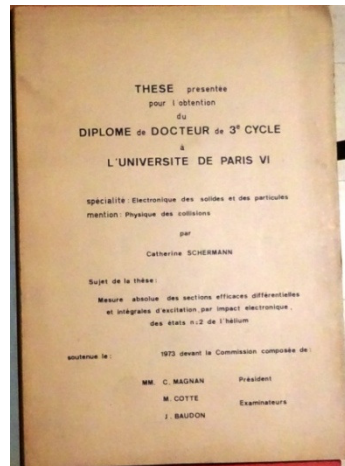
Michel Tronc  
- 1973



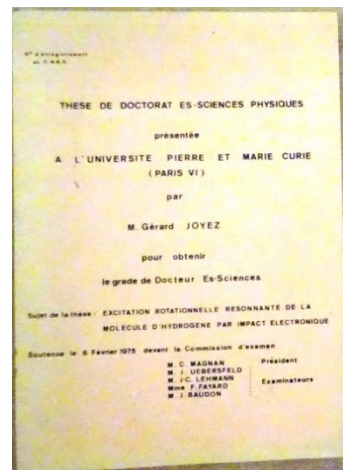
Françoise Pichou  
- 1977



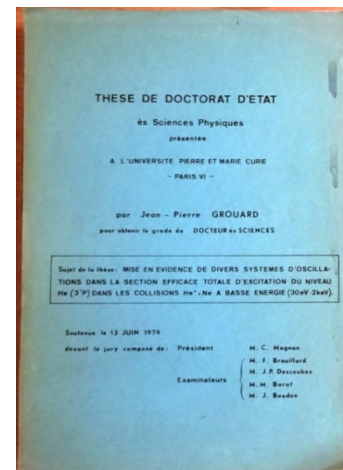
Alain Huetz  
- 1981



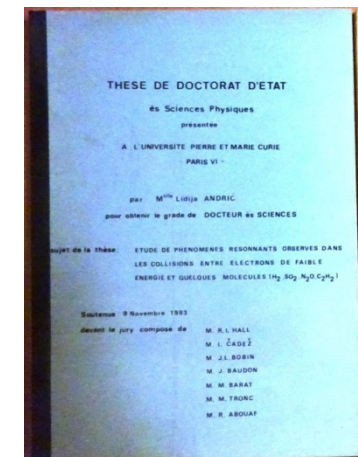
Catherine Schermann  
- 1973 3em C



Gérard Joyez  
- 1975



J.-P. Grouard  
- 1979



Lidija Andrić  
- 1985

# Electron-impact resonant excitation of molecular vibrations

## Electrostatic electron spectrometer An early result:

J. Phys. B: Atom. Molec. Phys., Vol. 6, May 1973. Printed in Great Britain. © 1973

### Electron impact excitation of $N_2$

#### I. Resonant phenomena associated with the $A^3\Sigma_u^+$ and $B^3\Pi_g$ valence states

J Mazeau, F Greteau, R I Hall, G Joyez and J Reinhardt

Laboratoire de Physique et Optique Corpusculaires, Université de Paris VI, T12-E5,  
11 Quai St Bernard, Paris 5e, France

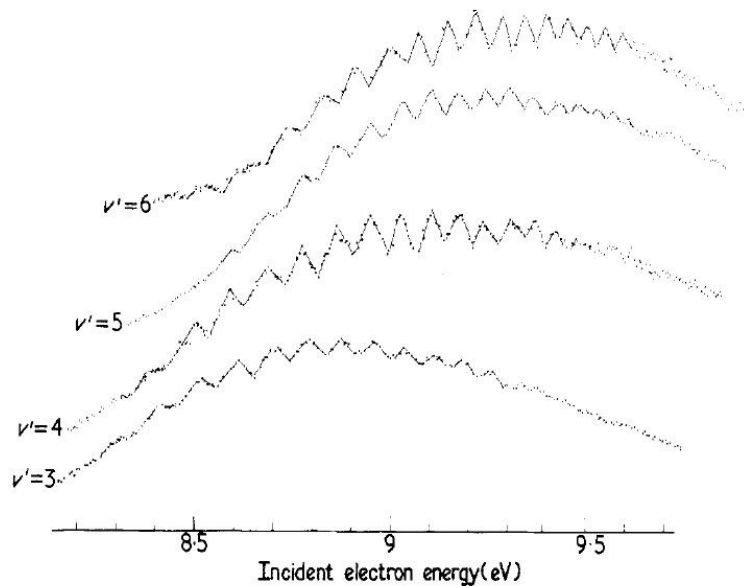
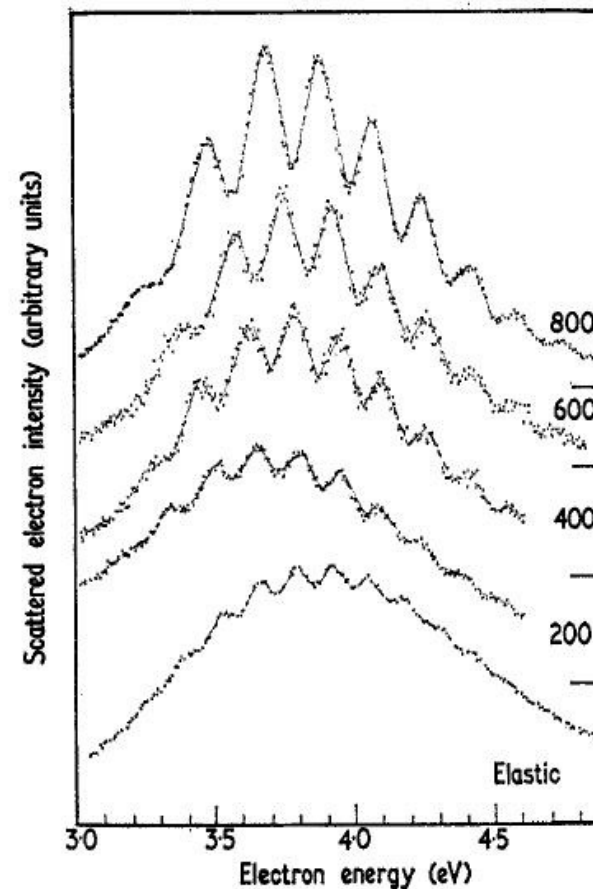


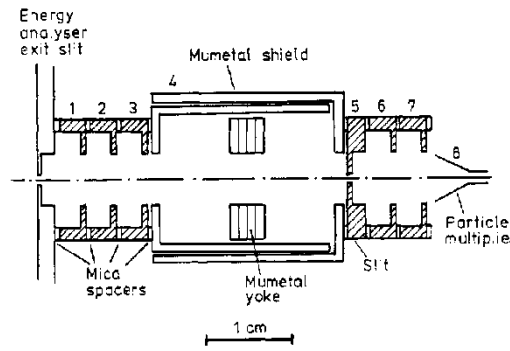
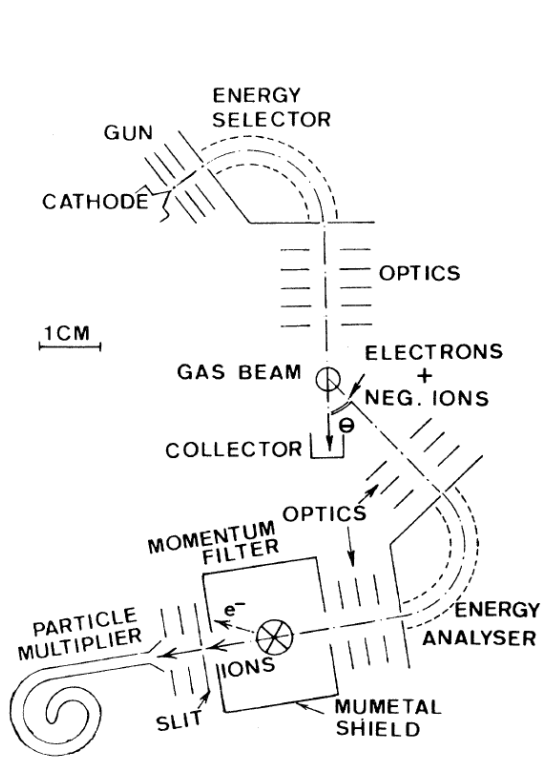
Figure 3. Differential excitation functions for excitation of the  $A^3\Sigma_u^+$   $v' = 3, 4, 5$  and  $6$  levels for a  $90^\circ$  scattering angle in the  $8.2$ – $9.7$  eV incident electron energy range.



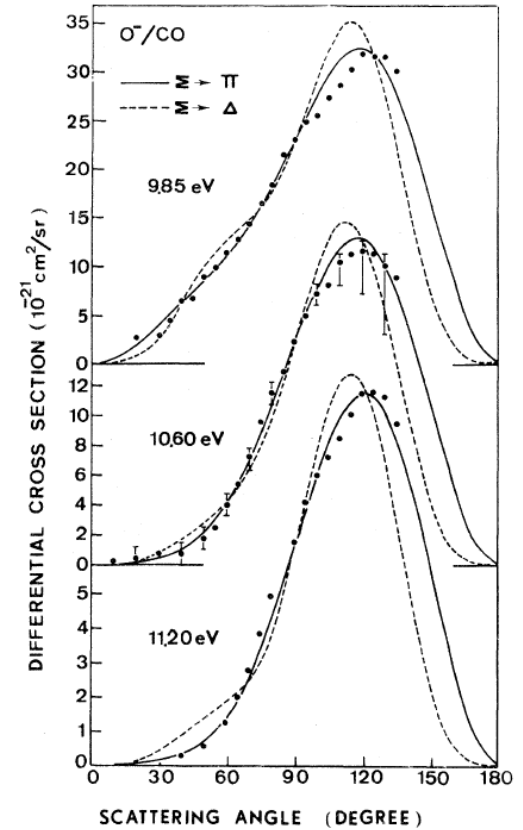
Soon later resonant excitation in  $CO_2$   
Boomerang effect - local complex  
potential model, with F. Fiquet-Fayard.

# Angular distribution of fragment anion

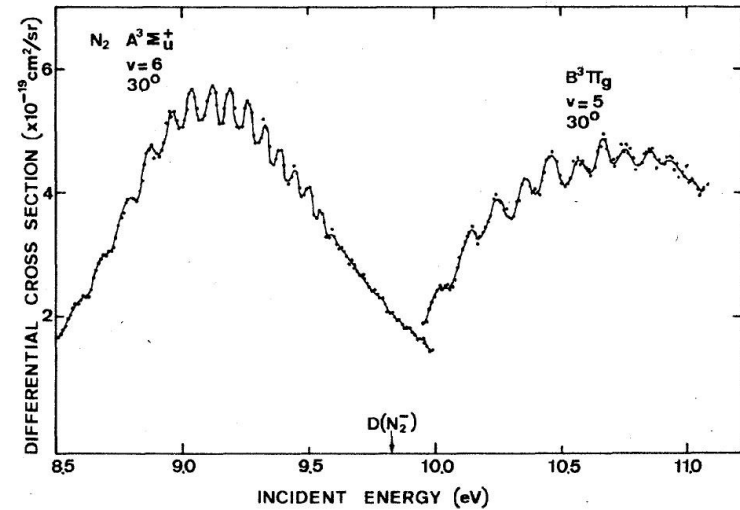
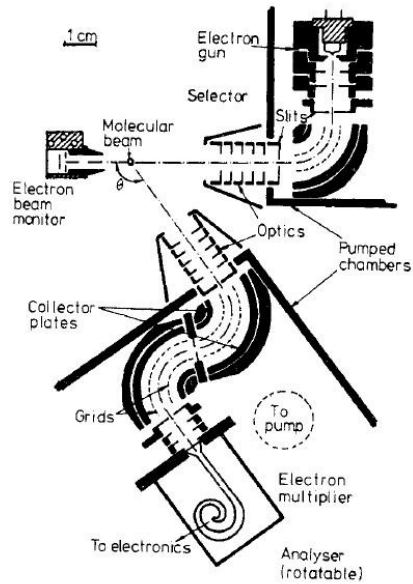
Charm of the experimental studies of atomic collisions is permanent development of elegant and more or less simple technical improvements!



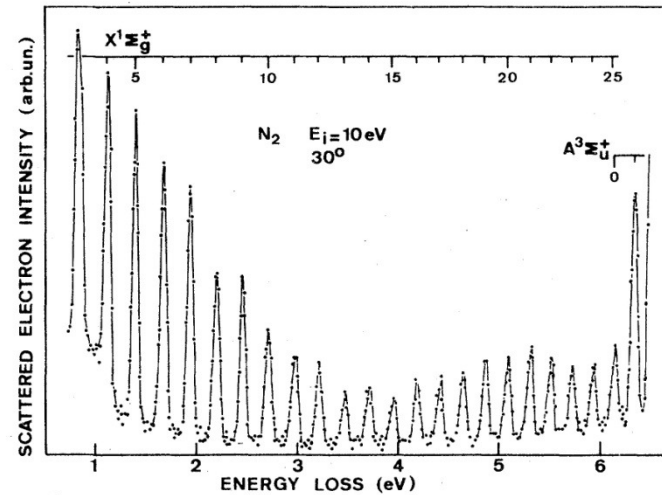
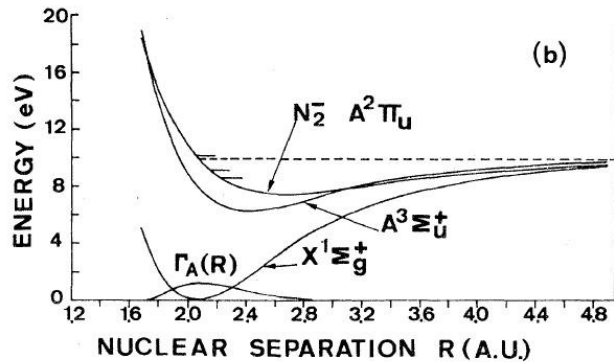
Modifying standard electron spectrometer by incorporating simple momentum filter for elimination of electrons allowed high resolution ion energy and angular measurements!



# High sensitivity spectrometer - REVE in N<sub>2</sub>

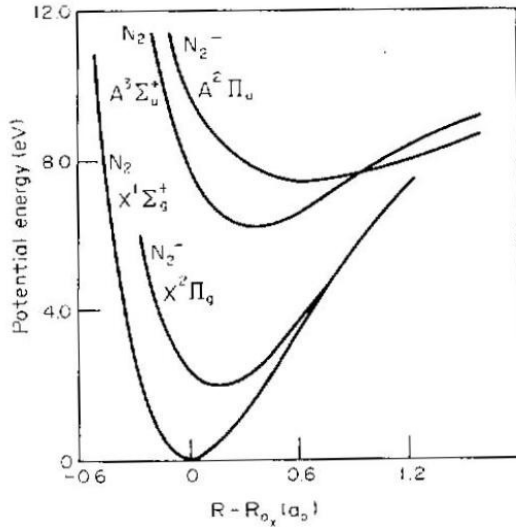


The state of the art high sensitivity electron spectrometer was built by F. Gresteau and later used by A. Huetz

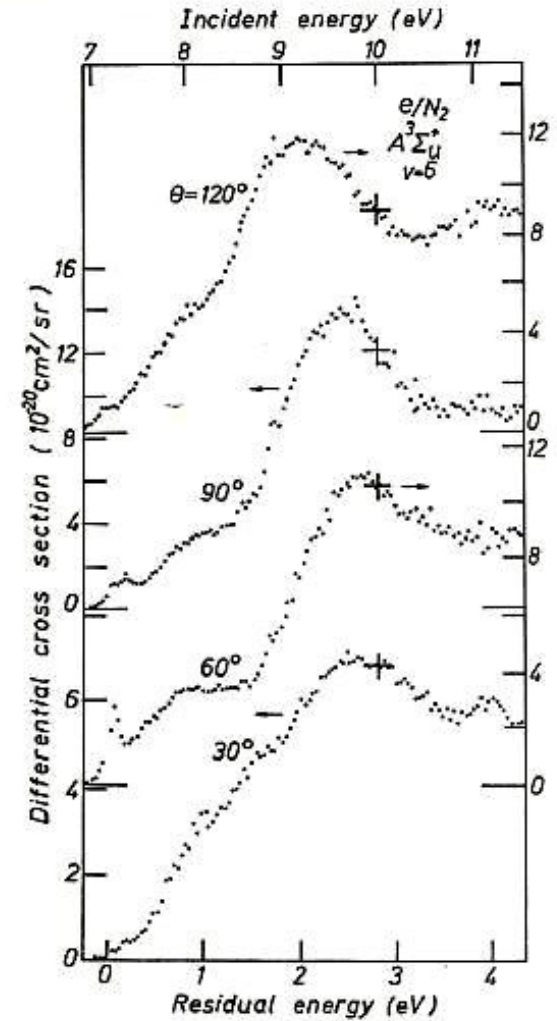
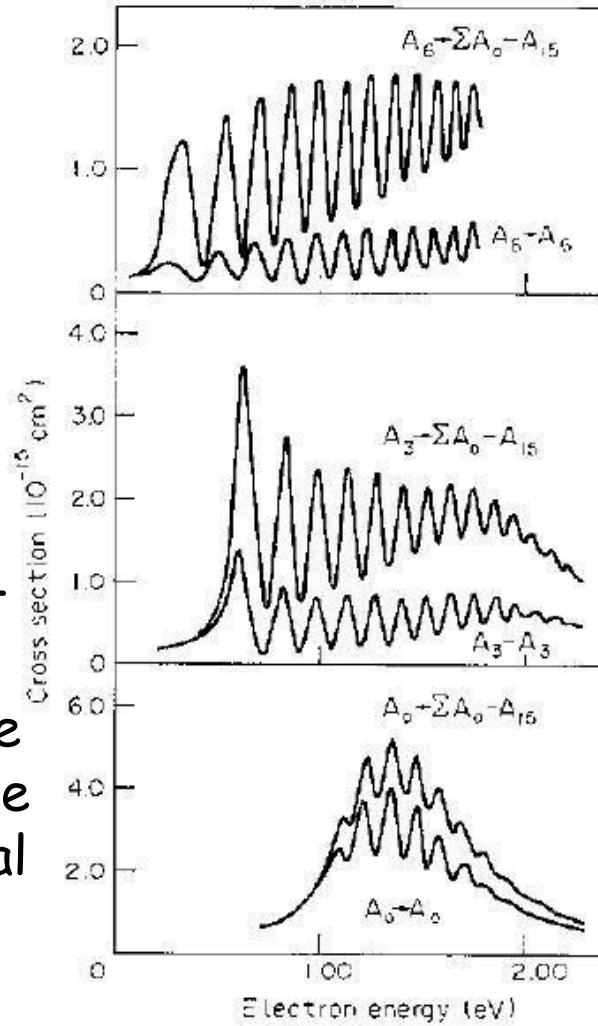




# REVE in N<sub>2</sub> / 2



Recognition of the importance of resonant electron collision with excited molecules (here  $A^3\Sigma_u^+$  in  $N_2$  with lifetime of 2 s!) and its potential relevance to atmospheric discharge and laboratory plasmas.





Although my collaboration with Jean Reinhardt did not last long time I kept warm friendship with him and his family for many years. Eventually we would have few joint meetings with old collaborators from LPOC on his boat-home or in some restaurant.

Collaboration between laboratory in Paris (LPOC, later LDMA and still later DIAM ...) and LAMC at IP Belgrade was wonderful, beneficial and fruitful experience. It was continuous (D. Belić, D. Popović, M. Kurepa) and it is still active (Lidija Andrić is permanent member of the Paris group, Tasko Grozdanov).

Collaboration was also established later between Paris group and Microanalytical centre, at Institute J. Stefan in Ljubljana (M. Žitnik, K. Bučar) where I moved in late nineties.

Lot of experimental now-how and also material and sometime instruments were provided to our laboratory in Belgrade. In 2004, when Paris lab had to move to another location, one entire experiment was moved on loan to Ljubljana.

## Some remarks on Science

Right to work in science (research) could be considered as one of human rights - it is need of creative mind.

The whole spectrum of researchers is needed for optimal development of knowledge.

Not **the best** but just **good** research to be stimulated.

Applied vs. fundamental research is to a great extent artificial division.

Collaboration between small/young and big/traditional research centers can be very fruitful and beneficial.

"Everything can be found anywhere if one goes deep enough."

# Some remarks on Science

## Science history and science "forensics"

- A new look at older papers and data yields sometime better understanding and possible surprise.
- Forgotten ideas.
- Forgotten technique.

## New time

- New communication techniques allow dissemination of data and scientific tools leading to unprecedented possibilities - global involvement of so called "citizen scientists"
- Large scale international collaboration on the daily basis
- Wise principles to be widely incorporated are needed in order to extent the life-time of our civilization

# Some final personal remarks

Growing together with young laboratories

Building the instruments

Quest for the new phenomena

My drive to enter experimental A/M work:

- "Are  $m_e$ ,  $q_e$ , ... indeed fundamental constants or they are different for each individual particle?"

My "dream" question:

- "How in detail happens absorption/emission of a single photon in/from an atom? - macroscopic vs. microscopic!"