Presentation

in remembrance of Vladilen Letokhov
at the 22nd International Conference
on Atomic Physics,
25-30 July 2010
Cairns, Australia

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Russia

In Memorial of Vladilen Letokhov

(November 10, 1939 – March 21, 2009)

It is a great honor to give a talk at this conference in memorial of Vladilen Letokhov.
For me he was at first as a superviser of my PhD work and later during more than 30 year as a great teacher and a good friend.

Among the participants of this conference I can see there are many people who knew him personally, met him at the laboratories and at the different meetings.

Vladilen Letokhov was one these rare few who was:

- ***The extraordinary Researcher***
- ***Physics pioneer***
- ***The scientist - Encyclopedist***
- ***The visionary Administrator***
- ***The gifted Teacher and Mentor***

From Siberia to Laser Science

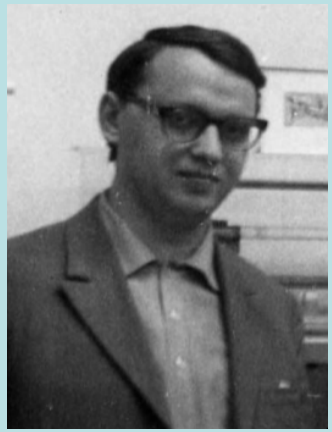
His road into big science started in 1957 when he has made his first trip from Siberia (where he was born) to Moscow where he became a student of Moscow Physical -Technical Institute.

The First Steps in Science and the good steps.

As a student he received
a first information about lasers in
lab of A. Prokhorov

The post-graduate course of N. Basov

N. Basov's graduate student diploma
on a statistical theory of photoheterodyning
of noncoherent and coherent light. 1963.



Prokhorov- Basov seminar was a great school
for him and a "stage", on which before his eyes
a new science was made.

I can give a of advice to young researchers.

"It is better to begin your career when you are a graduate student or post-doc in a most advanced research group. Then you automatically find yourself in the forefront of research.
And if you have corresponding abilities, you can show them exactly in the most frontier research.

I was lucky in this respect, but it was my own choice."

On the way to his first owned ideas

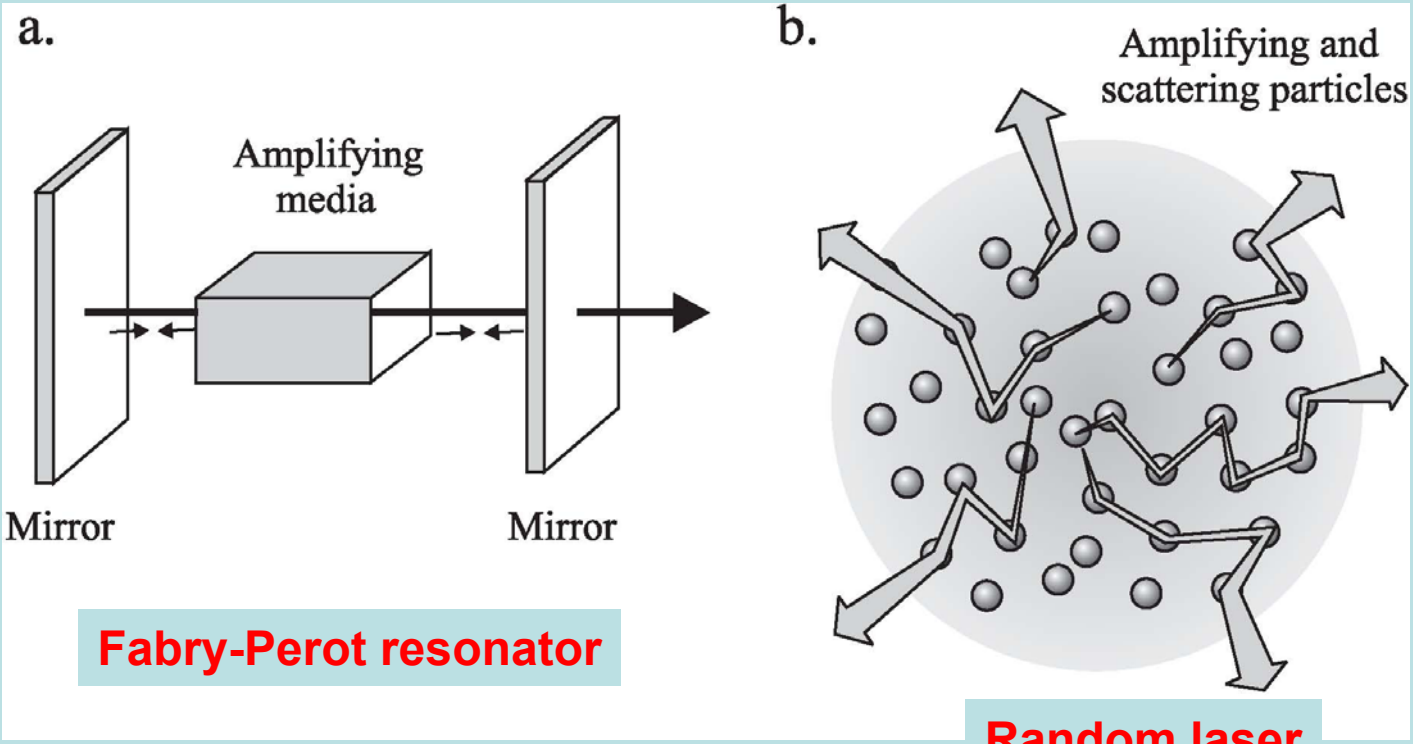
N. Basov was obsessed
by the laser thermo-nuclear fusion.
With the support of the government,
a of multi-cascade amplifier was built.

Being in a large laboratory and with great people is not always just a big advantage, but it could also be a great disaster. Letokhov in his book whote: "You feel yourself a tiny little nut in this huge machine."
I think that this situation is a good example when even a student can generate a great idea when he is small, but a smart nut of huge machine.

The Shiva amplifier chain

Letokhv observed that switching on the first two cascades already led to unexpected difficulties: amplifier easily is switched into regime of lasing - even at the insertion of a sheet of paper, which was used as a test screen at the optical alignment of amplifiers. The observation of this parasitic effect led to idea of a random laser.

The “random lasers”



Fabry-Perot resonator

Random laser

This work was forgotten for many years, but 20 years later it was restored to life under the name of “random lasers”.

Letokhov, V. Light generation by a scattering medium with a negative resonant absorption. *JETP* 16, 835 (1967)

Elimination of Doppler broadening

(Basov, maser, seminar in FIAN)

One of the trends of the research in the Basov Lab was a creation of microwave oscillators with high frequency stability (atomic clocks).

Basov advised to Letokhov to take up the problem of lasers with highly stable frequency.

In order to obtain the stability of frequency on the level of 10^{-12}-10^{-13}, it was necessary to have a spectral resonance, with the relative width of 10^{-9}-10^{-10}

By sub Doppler resonances

The first idea was to use Lamb dip of saturated absorption of CH_4 in a cell, which was inside the cavity of He-Ne laser 3.39 μm

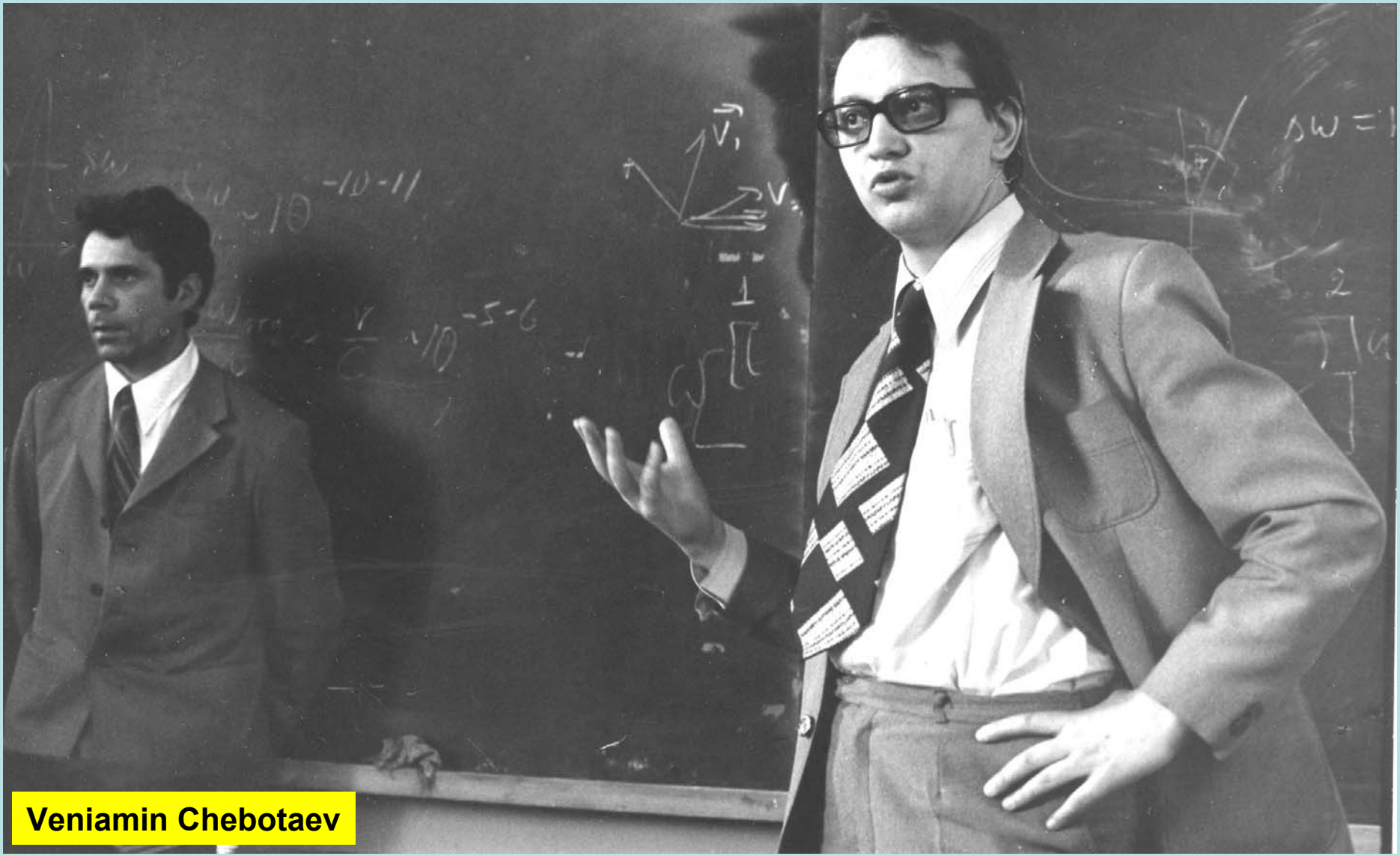
Letokhov, V. (1968). Doppler line narrowing in a standing light wave. *JETP Lett*. **7**, 272-274.

Two years later this idea was brilliantly realized by John Hall in Boulder.

Later Letokhov and Chebotaev worked together on the problem of high frequency stable lasers and wrote several joint papers including a book: *Nonlinear Laser Spectroscopy,* 1976.

Ten years later they were awarded for these joint works the most prestigious prize in USSR, the Lenin Prize in Science and Technology.

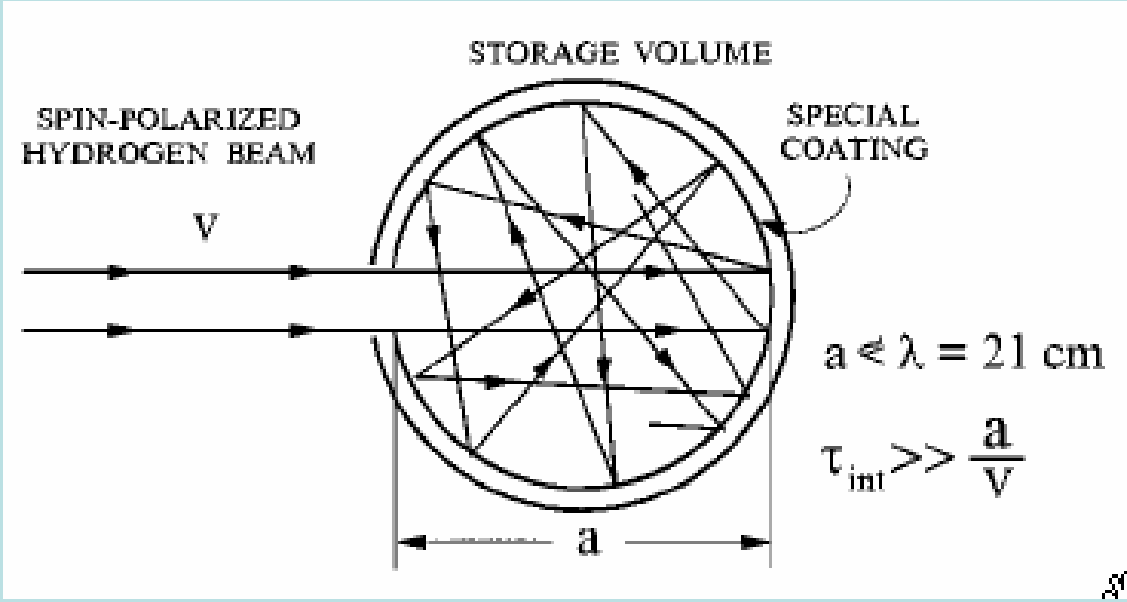
More than 20 years of friendship and partnership



Illumination of Doppler broadening by molecular trapping

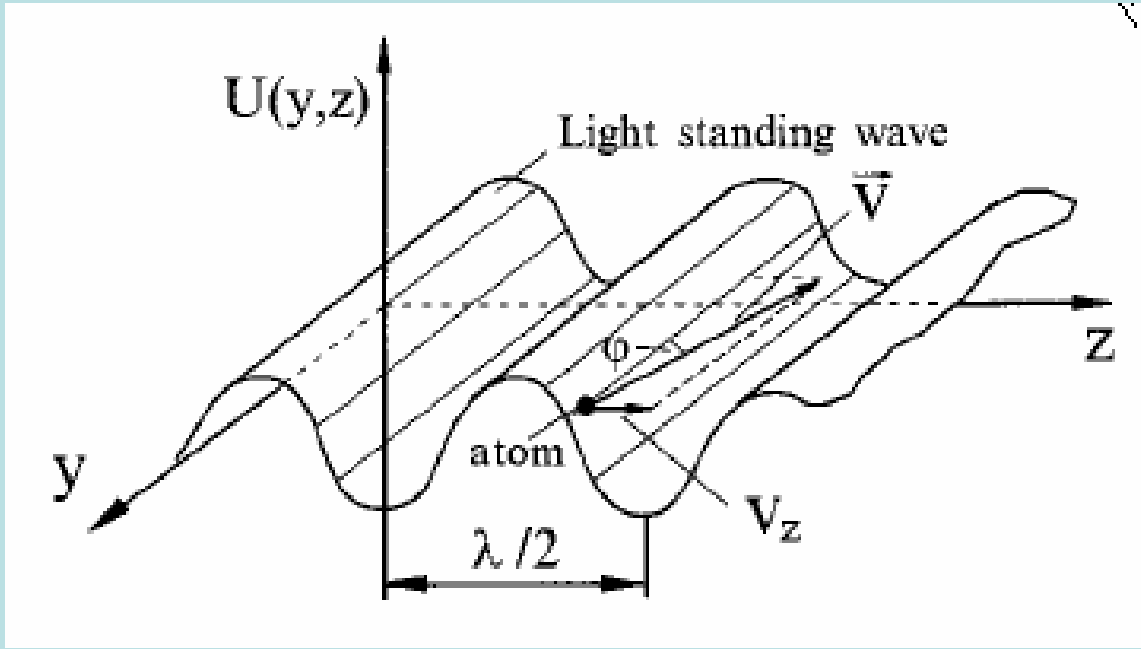
Another idea of illumination of Doppler broadening :
to put an assemble of moleculars in a region << λ

The work by Kleppner and Ramsey about hydrogen maser with storage bulb, restricting the Doppler broadening of 21 cm line according to Lamb-Dicke idea of restriction of their motions in size less than radiation wavelength.



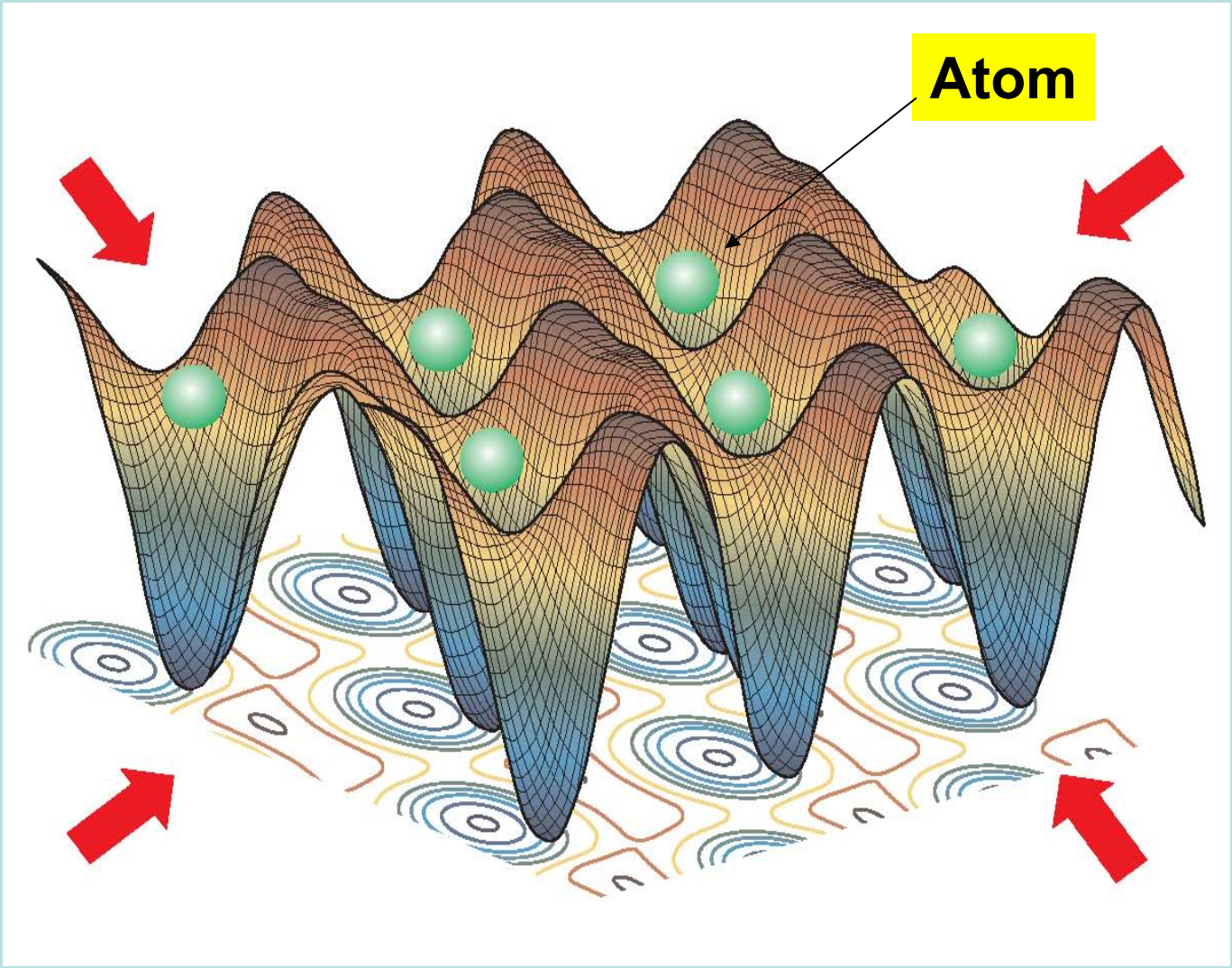
Idea of illumination of Doppler broadening: to use the potential gradient force

Scheme of the 1D trapping of atoms in the periodic potential *U(y, z)* produced by a standing laser wave

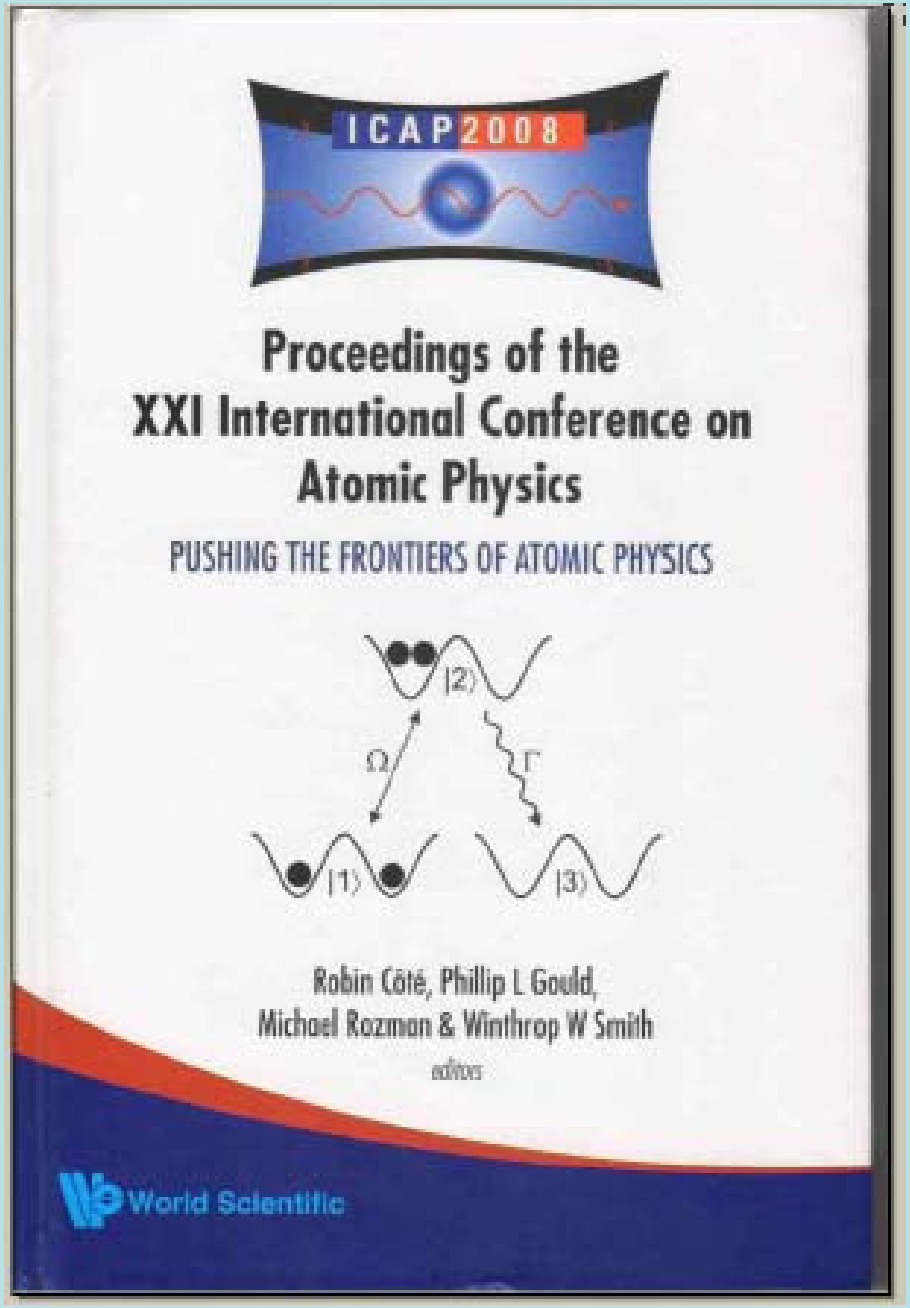


Letokhov, V. (1968). Doppler line narrowing in a standing light wave. *JETP Lett*. 7, 272-274.

Atoms in a standing wave is known nowadays as an optical lattice



A lot of applications after the invention of methods of laser cooling of atoms.



Still - light standing wave

In the middle of the 60'ies, the Basov's laboratory was concentrated on the idea of a megajoule laser that seemed "engineering" to Letokhov.

…it could be possible to use more cleverly the unique but limited in energy possibilities for the action of laser light on the matter….

He left Basov's lab.

At thirty… and All at Once !!!

At 1969 Letokhov left the Basov lab and became a depute derector of ISAN
The two years (1969-1970) were the vital years in scientific career of Letokhov.

October, 1970 — **Javan's laboratory in MIT**

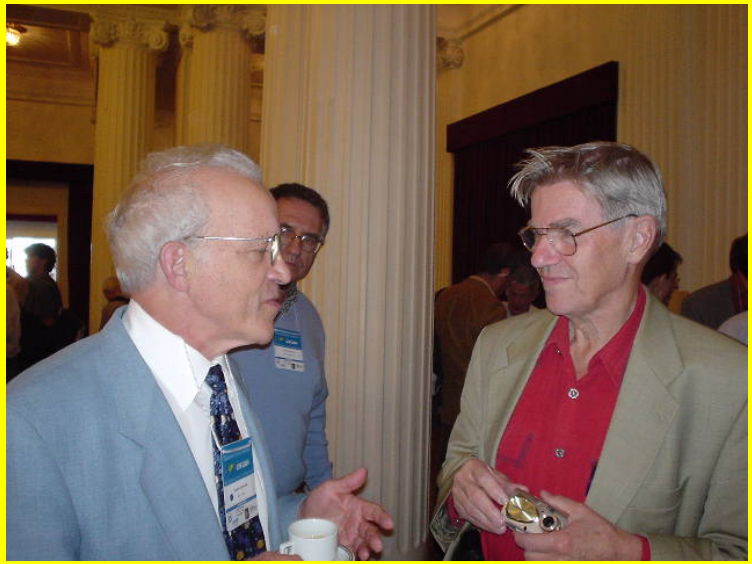
June, 1970 — **The deputy director of Institute of Spectroscopy**

November 1969 — **Defense of PhD and Doctor of Sciences thesis**

November, 1939

MIT - another Alma Matter

- 3 - month exchange visit - A. Javan's laboratory in MIT
- The highlights of the visit to MIT - a meeting with D. Kleppner
- NBS in Boulder – John Hall
- California University at Berkeley – Charles Townes, Ted Hansch
- Stanford University
- IBM Research Laboratory
- Harvard University - N. Bloembergen
- Yale University - W. Bennett



Results of 3-month tour in USA

He summarized his three month visit in USA as:
….as a result of the 3-month tour of the most advanced laser research laboratories of the USA I received quite a clear idea of the forefront of this research.
In addition to it, I saw that the laboratory equipment for the laser research differs greatly from our equipment.

…in connection with this I can give advice to young professors, who start their laboratories, – to make a several month tour to the best international laboratories in order to learn their practical experience, research methods.

Nowadays it is usual practice in many countries.

Javan and Letokhov 30 years after the first meeting at MIT

Another results of this visit was :
A very productive scientific contacts and a very warm and friendly relationships for many years.

Letokhov and Moore

The methods of laser separation of atom and molecules was a topic of a long and productive cooperation between **Letokhov and Moore**.

C. Townes and A. M. Prokhorov at their visit of ISAN

ICAP 2006

Near 40 years Letokhov was a head of Department of Laser Spectroscopy

The main area of his scientific interests

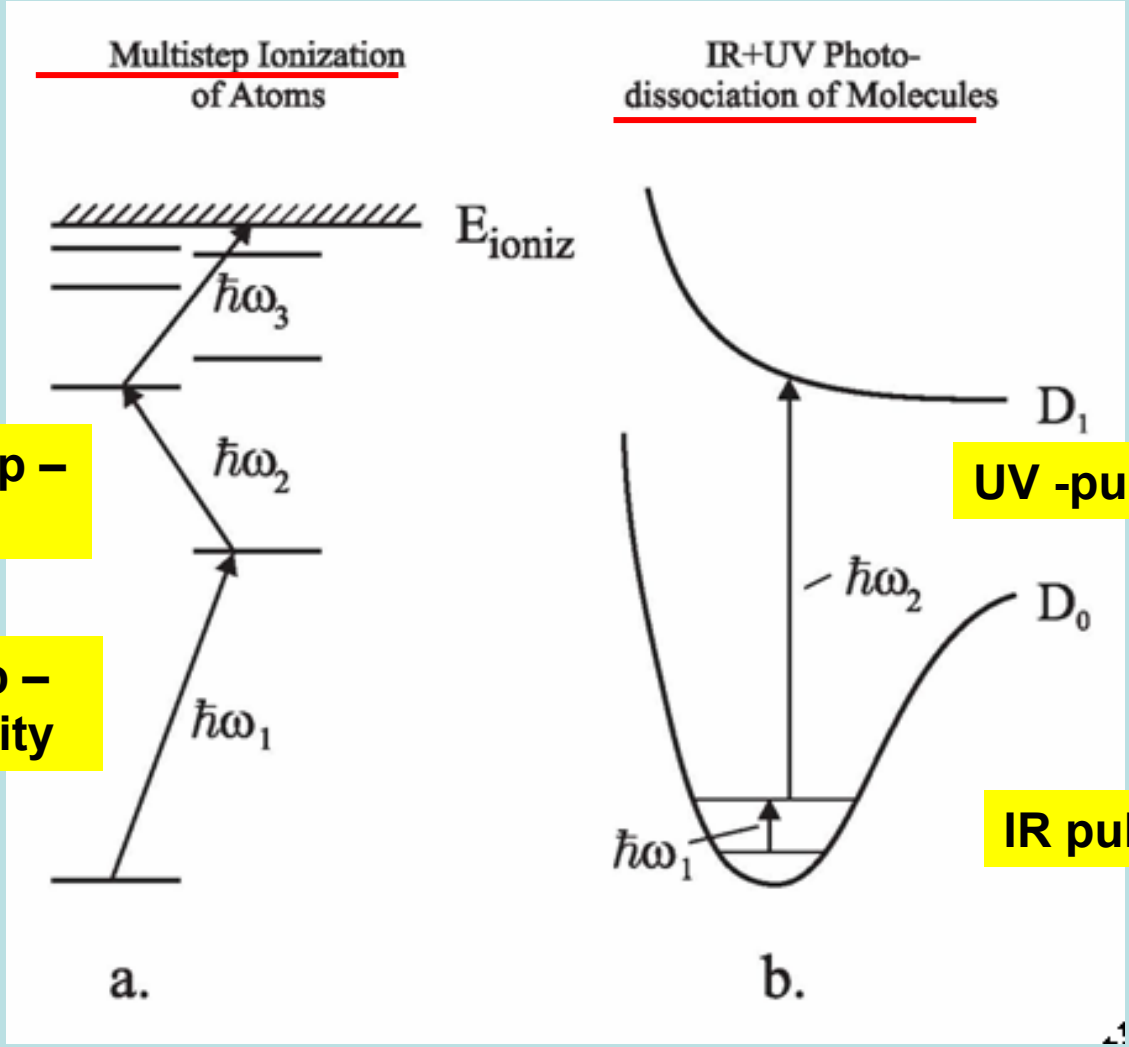
- Photoselective effect of laser radiation on atoms and molecule.
- Realization of the ultimate sensitivity in spectroscopy, selectivity and spatial resolution.
- Laser control of atoms and molecules.
- Laser in astrophysics

His heritage contains

850 publications

16 books

Enhancement of the selectivity of nonresonant photoionization and photodissociation processes by means of two laser pulses



The second step – high efficiency

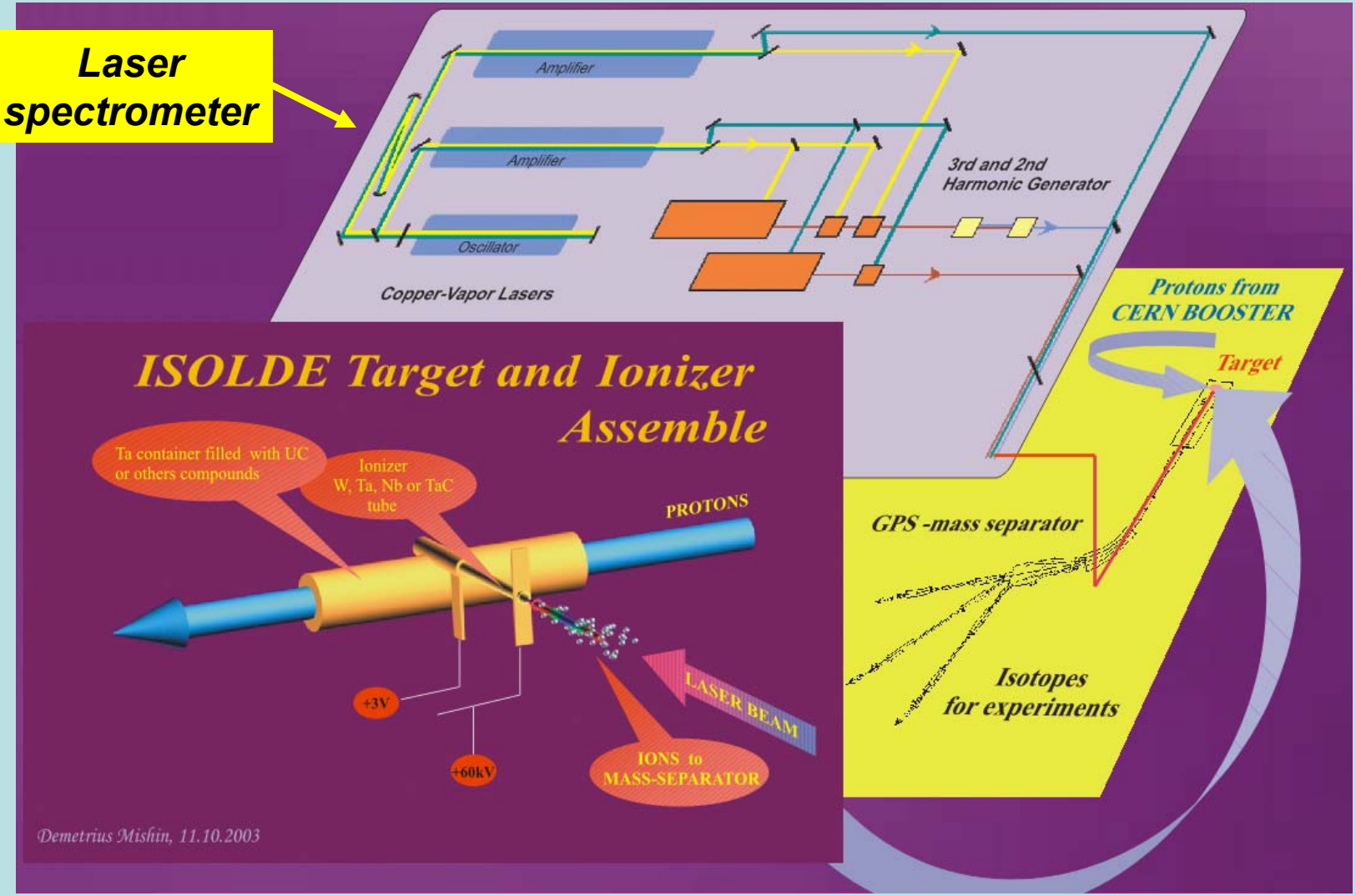
The first step – high selectivity

UV -pulse

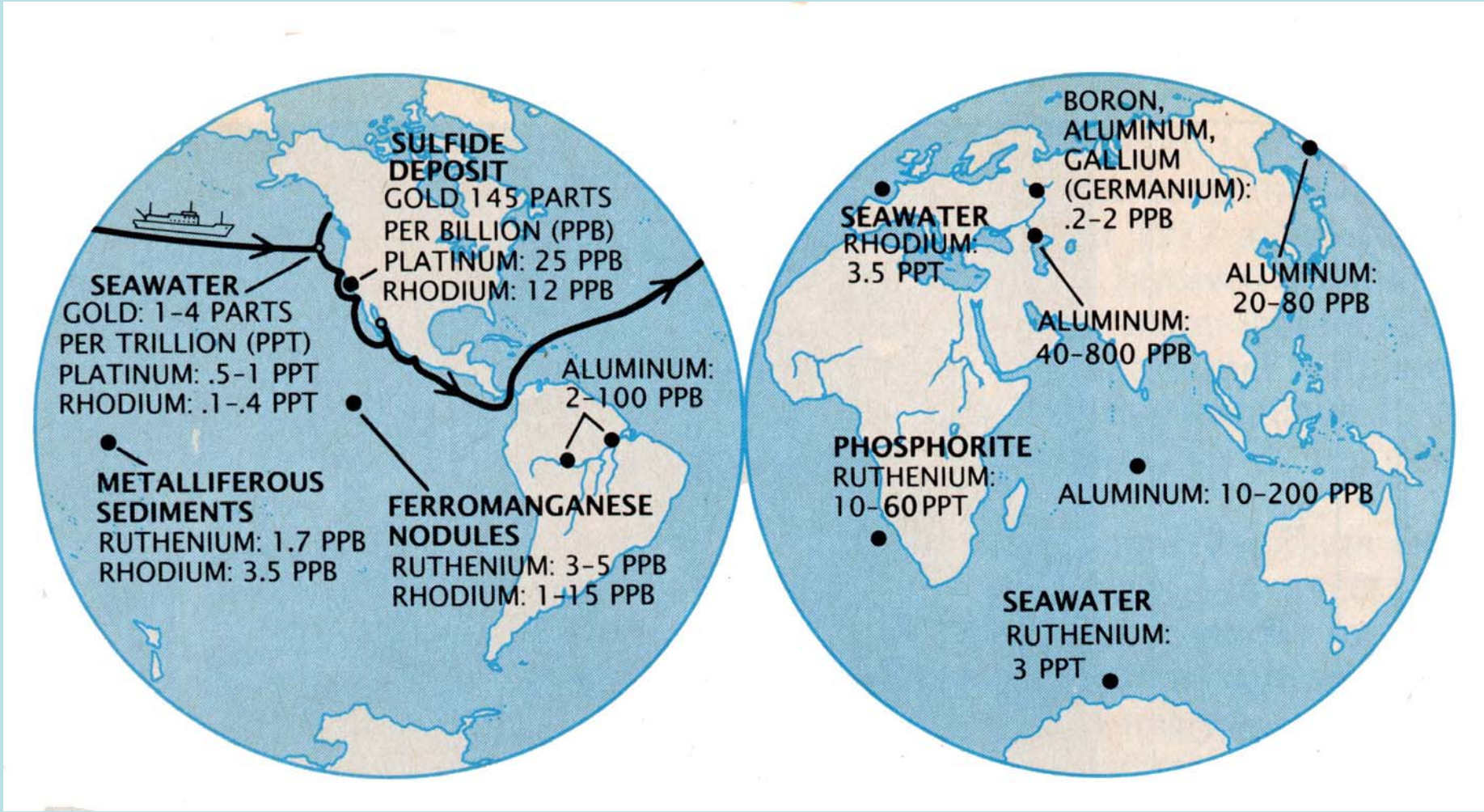
IR pulse

The experiment in lab: Rb atom and molecule of NH_3

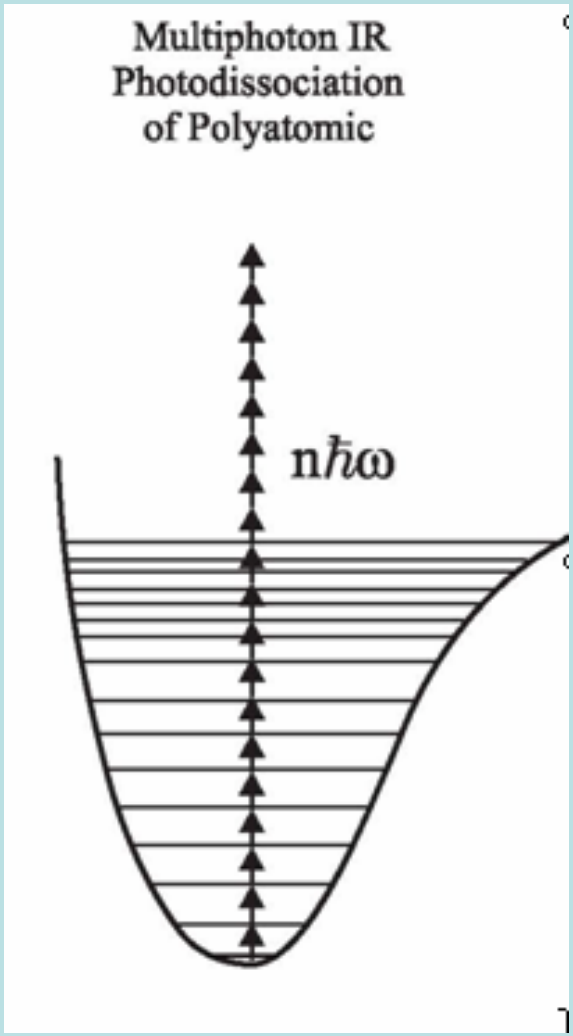
A long term collaboration between Inst. of Spectroscopy and CERN was established on a use Multistep Ionization of Atom

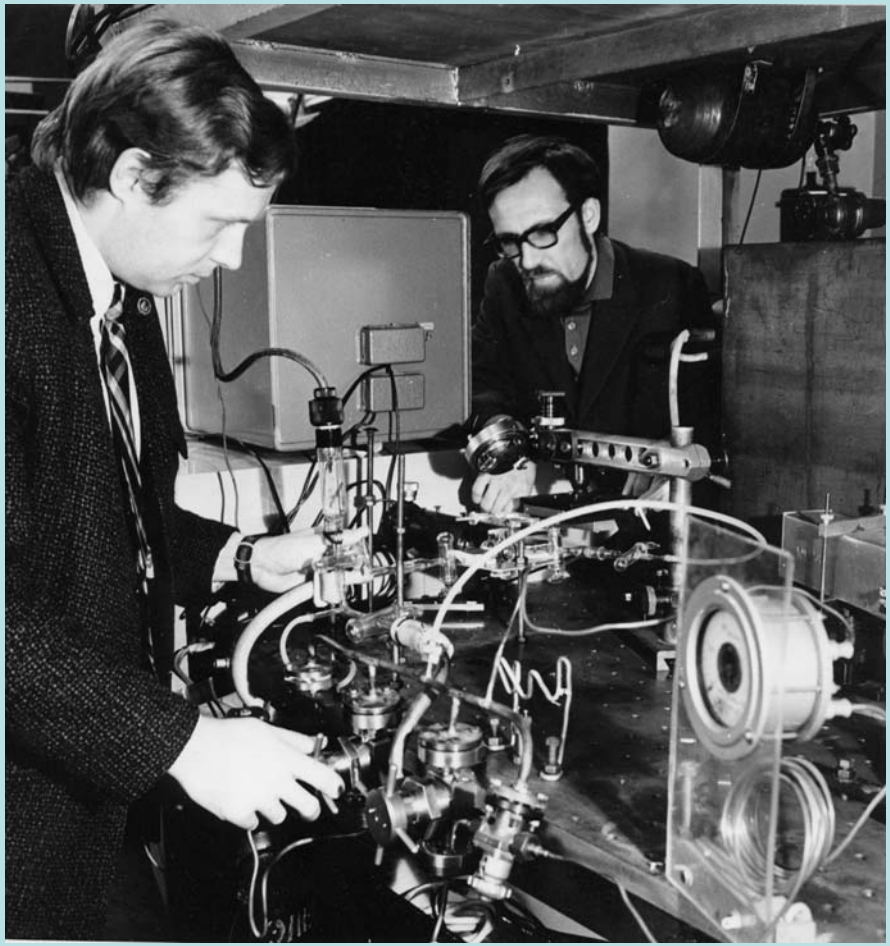


Multistep Ionization of Atoms became the most sensitive methods for measurement of trace elements in seawater, river water and various sediments.
The resonance-ionization spectrometer (made in ISAN) on the research ocean shipboathas made a cruise to make **measurement of** trace elements in seawater.



Isotopically-selective multiphoton excitation and dissociation





The first experiment:
E. Ryabov, N. Chekalin

Industrial production of carbon isotopes on the base of IR MPD

Laser source: PR TEA CO_2-laser (1.8 kW)

Molecule : Freon-22 (CF_2HCl)

Production rate: ~ 10 kg/year ^{13}C (x >30%) per module

He was awarded for these works the most prestigious prize in Russia, the State Prize in Science and Technology

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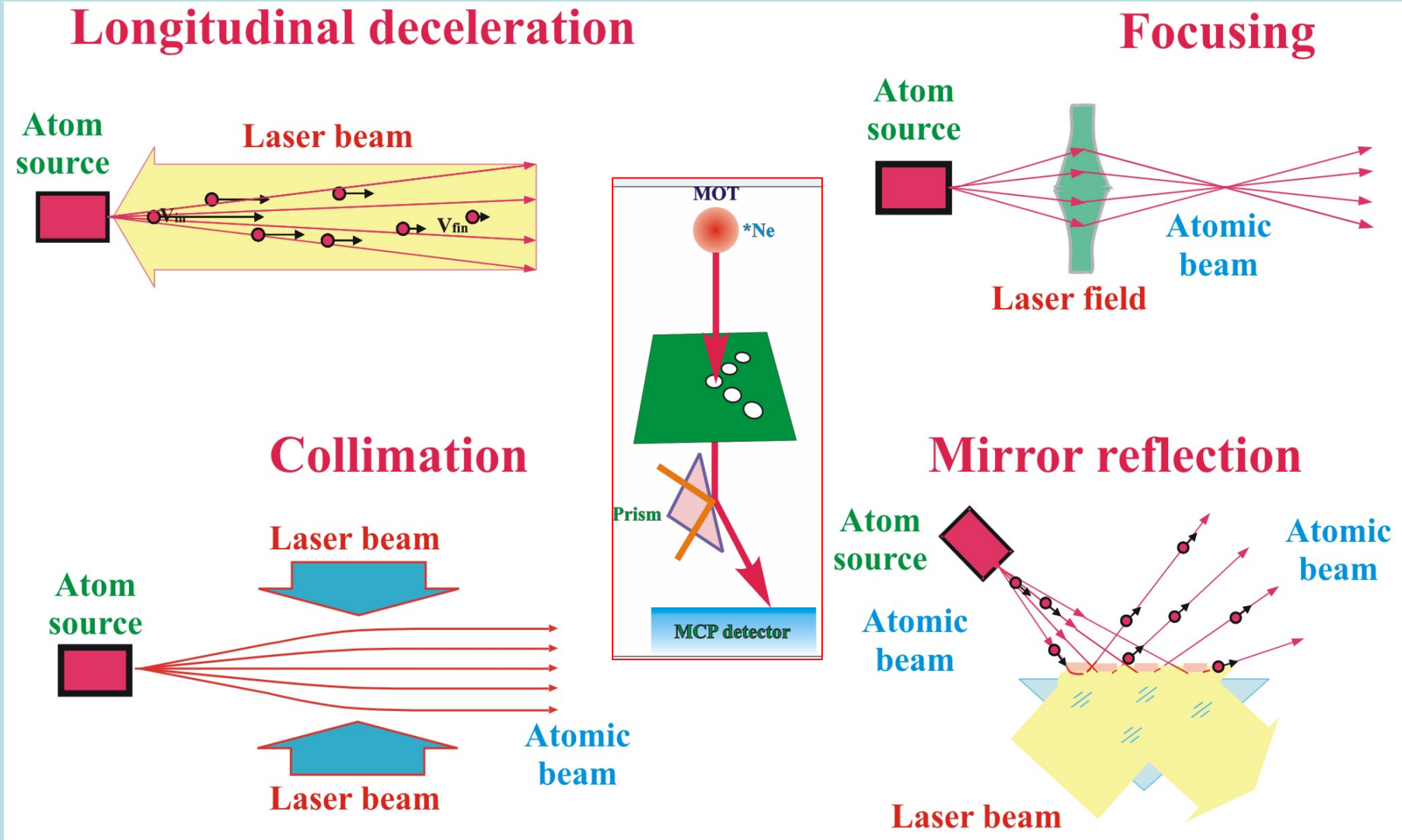
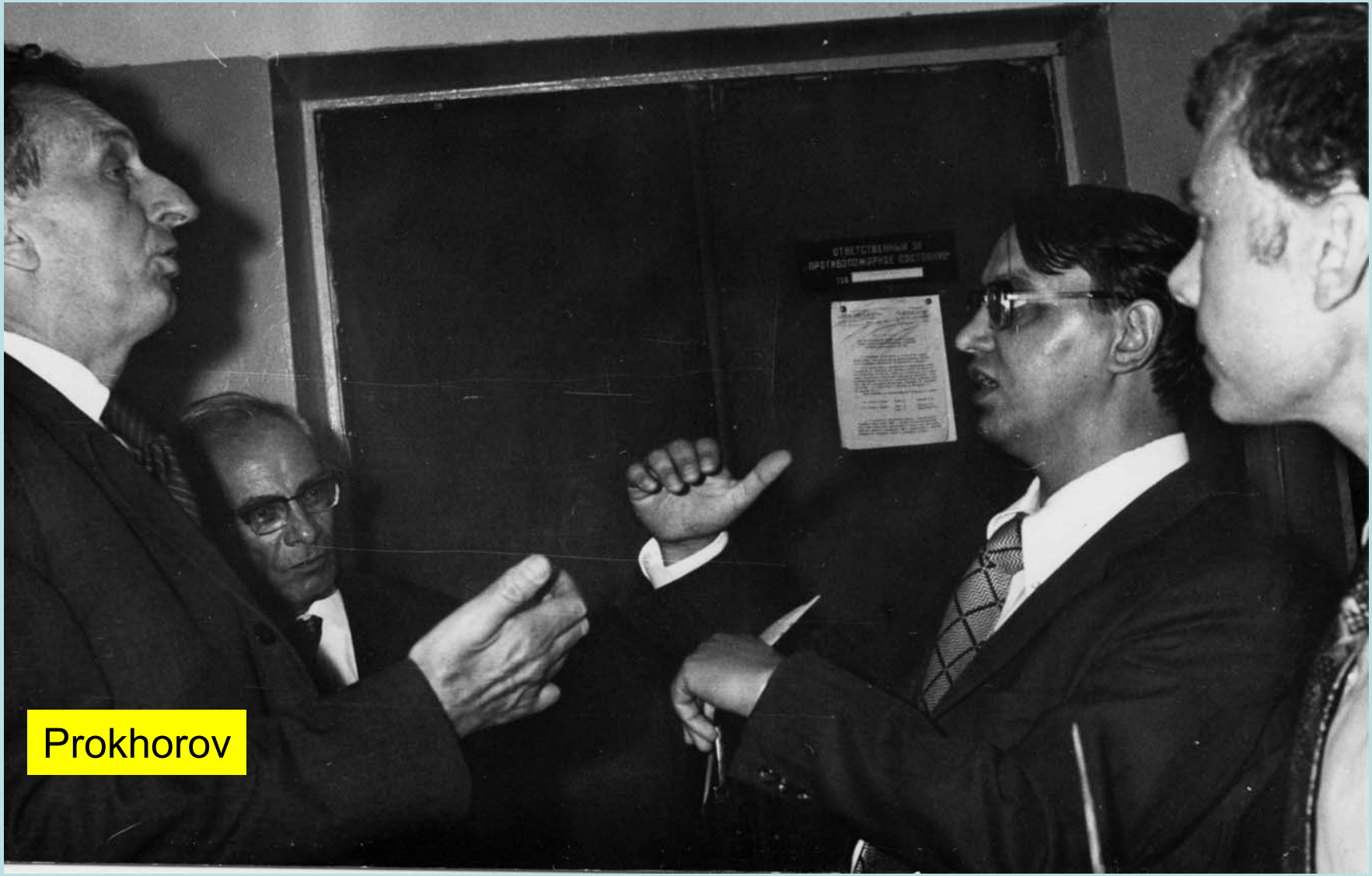
…there are no small things in a real experiment

This picture remind me an episode in our experiments with laser cooling of Na atoms: the main laser in this experiment was a dye laser. We built it and it was a rather nasty devices which contains a jet nozzle for dye solvent. The jet nozzle was made from razor blades and in Russia the blades were not a very good quality. Letokhov was at some conference in Germany and I asked him by phone to bye all kinds of razor blades. He did it and as a results we succeeded in getting a frequency stable laser beam.

Laser Cooling and Trapping. Atom Optics

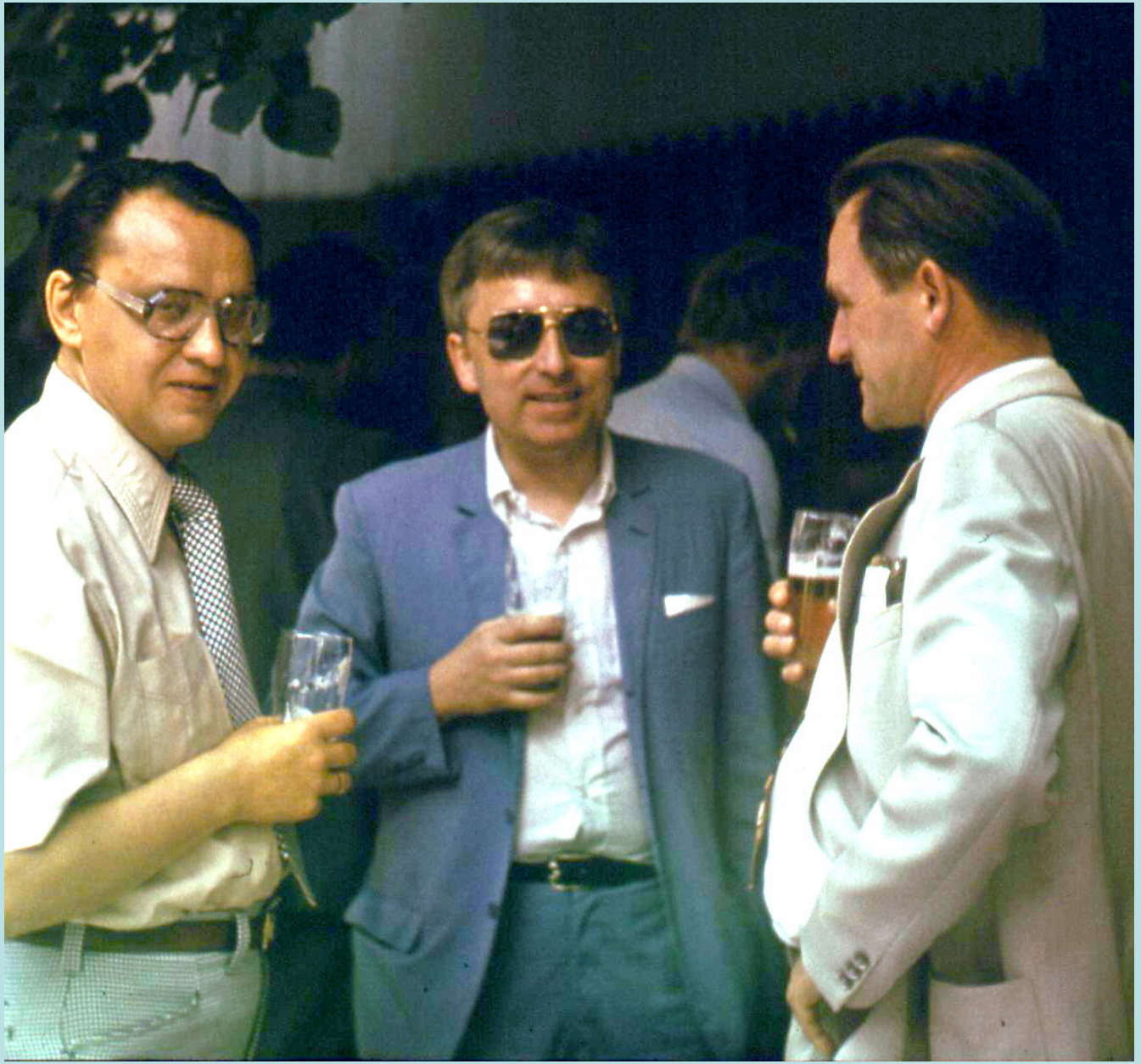


The visionary Administrator



Letokhov was a very gifted administrater. On this photo – an episode of a Prohorov's visit by our Institute. On o photo you can see a previous director of our institute Mandelschtam who invited Letokhov to become a depute director of ISAN. I thing it was a very wise decision of Mandelsctam: all administrative duty was put on the shoulders of Letokhov.

Coffee (beer?) break at German – Soviet Symposium



The years of «perestroika»

At the beginning of perestroika he felt the forthcoming radical changes
and he completely stopped applied research

Letokhov organized through Peter Franken a funding the leading Russian research centers from The Laser Department of Lawrence Livermore Laboratory through Department of Energy, USA

The scientist – encyclopedist

The scientific interests of Letokhov were really **enormous.**

- Atomic physics
- Laser physics
- Spectroscopy
- Chemistry
- Biomedicine
- Astrophysics
- Lasers application to nuclear physics

The gifted Teacher and Mentor

“Good teaching is always a performance”

1. Training and mentoring of palette of students and young scientists
2. Sending abroad PhD student and young scientists: in Europe and USA
   it is a rather trivial step; in SU it is a hard job to send a person in another lab.
3. Physics is not only a hard job but it is joy and a passion
4. Every day evening talk

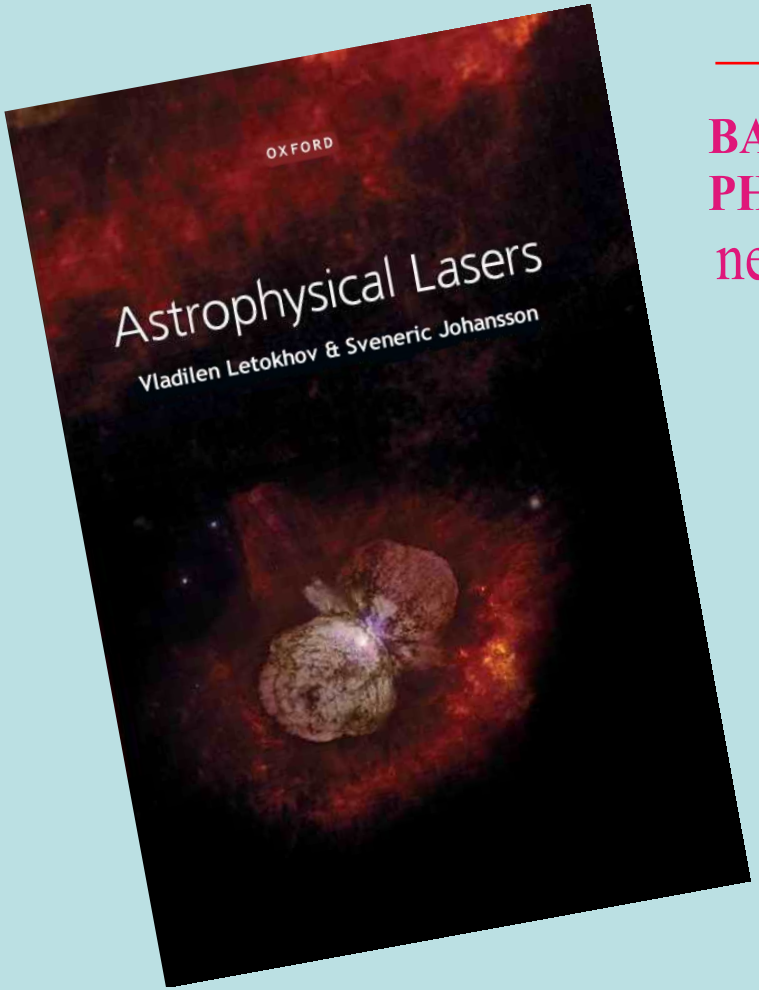
The first and the last passion: Astrophysics

- As a student he bought the book “Lines of the Chemical Elements in Astronomical Spectra” by P. Merill (1956).
- ….a lot of interesting remarks on puzzled stellar spectral lines was in this book.
- At 70’ies these facts revealed themselves with the guess about the probable connection of these lines with laser effect.
- Two lines of UV radiation of the iron ions of gas condensations and not of the central the star Eta Carinae itself were anomalously bright (Hubble Space Telescope).

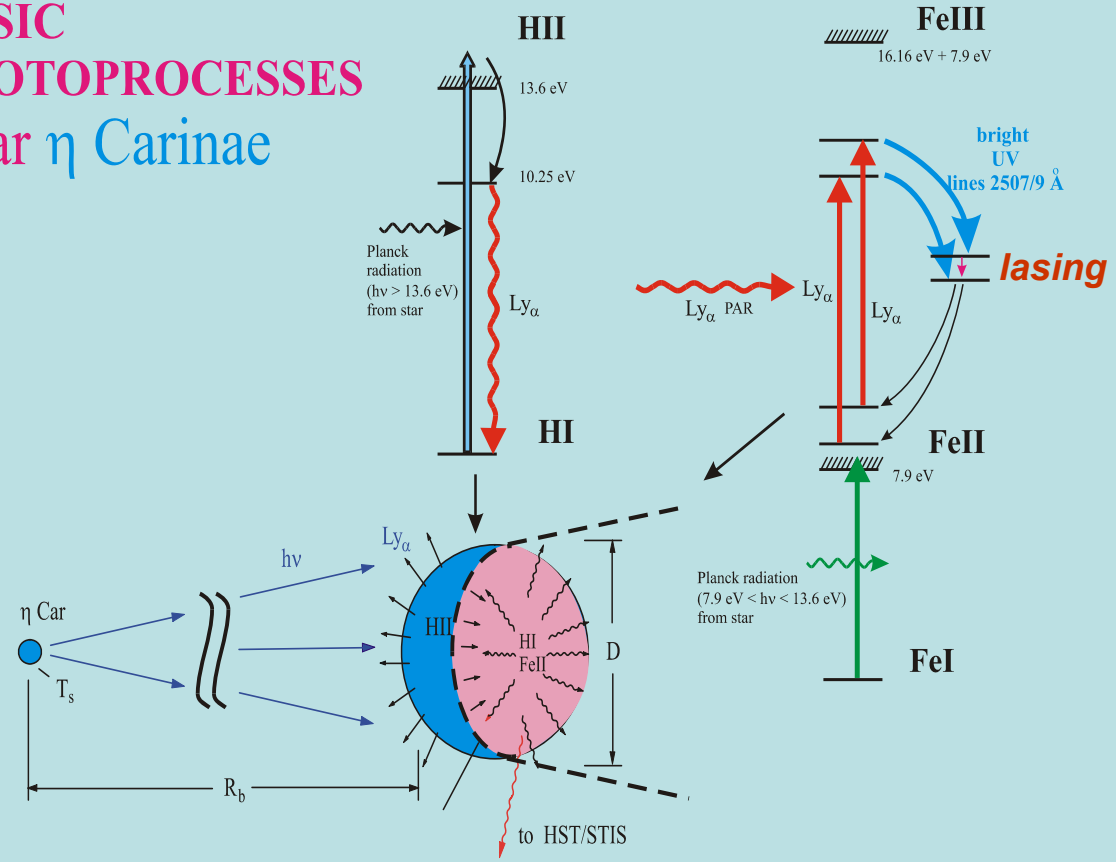
S.Johansson V.Letokhov

Astrophysical Lasers in optical range on the lines FeII near *η Carinae*, excited by Ly_α HI.

Laser action: **FeII ≈ *1 μm;* OI = *8446 Å***



BASIC PHOTOPROCESSES near η Carinae



…there is no great man without great woman

This photo was make after Russian-German seminar on laser physics.

Prof. Lamb- during his visit Institute of spectroscopy

I miss him terribly

And
I know that there are many of us who feel that way