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Short Course

**MODERN LASER
TECHNOLOGIES**

**Laser processing of materials:
fundamentals and applications**

Russian Academy of Sciences

***A.M. Prokhorov* General Physics Institute**





Russian Academy of Sciences
A.M. Prokhorov General Physics Institute



Alexander M. Prokhorov

- 1964 – Nobel Prize winner
for fundamental investigations in quantum
electronics that led to creation of lasers and
masers





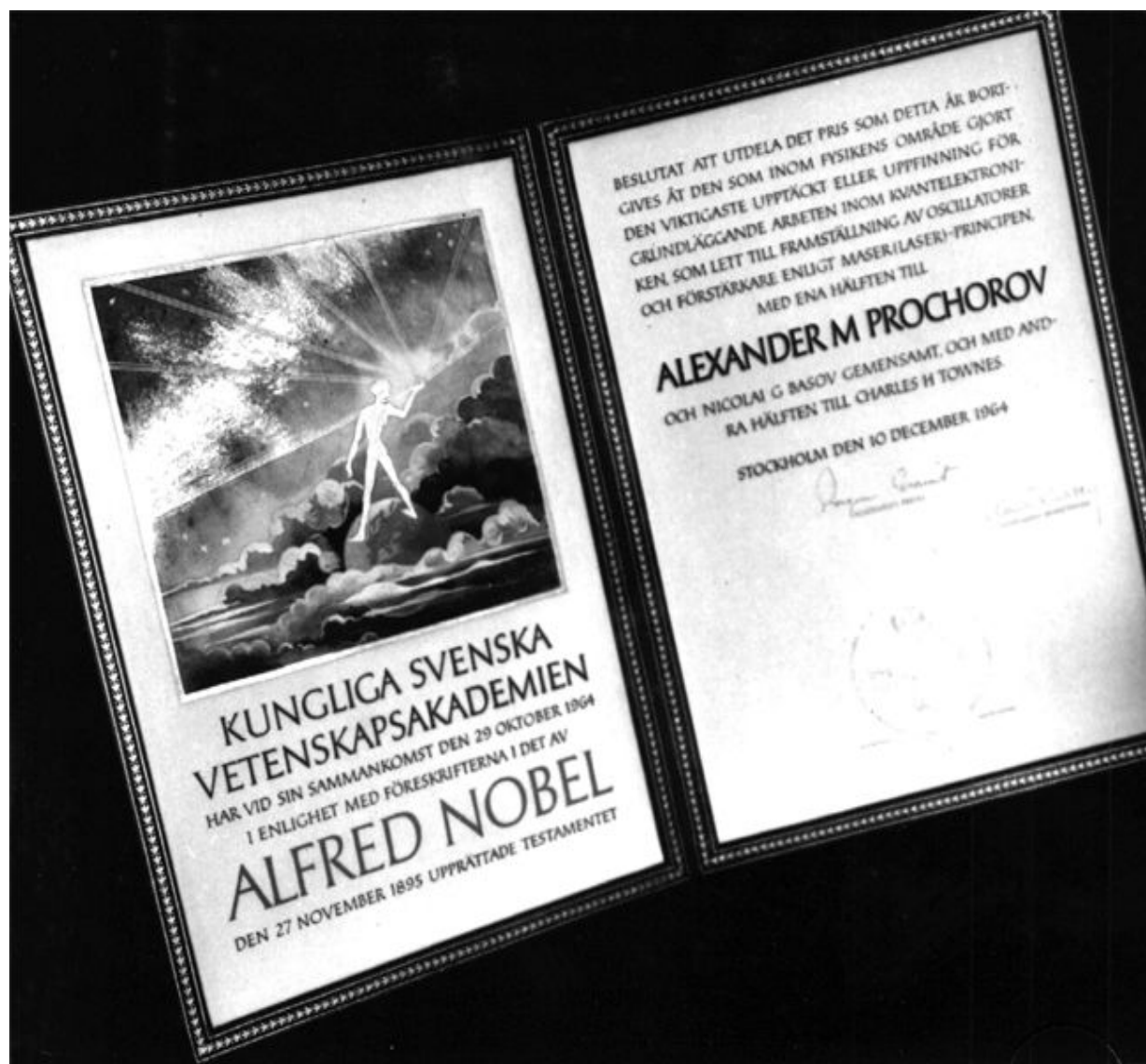
Конец 1965: А. М. Прохоров, Ч. Х. Таунс и Н. Г. Басов в Физическом институте Академии наук



Карл Август VI вручает диплом нобелевского лауреата и медаль А. М. Прохорову



Natural Sciences Center of General Physics Institute (NSC GPI)
RUSSIAN ACADEMY OF SCIENCES



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Нобелевская медаль А. М. Прохорова





Major Fields of Research

- Physics of condensed matter
- **Optics and laser physics**
- Radio-physics, electronics, and acoustics
- Plasma physics



Optics and laser physics

1. Classic and quantum optics
2. Nonlinear optical phenomena, materials and devices
3. Ultrafast phenomena in optics
4. **Laser-matter interaction, laser technologies**
5. Fiber optics and optical communication. Integrated optics.
6. Optical informatics and holography
7. Methods of spectroscopy and luminescence.
Precision optical measurements
8. Laser physics and laser materials
9. Lasers in physics, chemistry, biology, medicine, ecology, and industry
10. New optical materials, technology and devices

Contents

1. Introduction

- most important parameters of laser radiation;
- modern technological lasers

2. Irradiation schemes:

- beam focusing;
- image projection;
- diffractive optics;
- scanning

3. Optical properties of materials:

- reflectivity and absorptivity, absorption coefficient and experimental techniques of their measurements;
- difference between ideal and real optical surfaces;
- interference phenomena;
- role of temperature and phase transitions;
- effective energy coupling regimes

4. Phenomena induced by low intensity radiation:

- fluorescence;
- generation of charged carriers;
- photoemission of electrons;
- photo and thermo desorption;
- thermo diffusion;
- surface electromagnetic waves

5. Laser heating of solids:

- major parameters;
- one-dimensional and spherical approximations;
- useful expressions.

6. Thermoelastic surface deformations:

- theoretical model;
- short and long pulse approximations;
- surface profile distortion;
- irreversible material damage.

7. Laser ablation:

- surface melting;
- evaporation threshold;
- steady-state ablation;
- ablation without heat diffusion;
- liquid material expulsion by vapour plume.

8. Laser induced surface structures:

- examples;
- resonant and non-resonant surface structures;
- theoretical approach.

9. Laser-produced plasmas:

- laser heating of ionized gases;
- electron avalanche;
- plasma formation in vapour plume;
- vapour plasma expansion into vacuum;
- optical gas breakdown;
- laser supported absorption waves;
- energy balance.

10. Surface chemical reactions:

- classification;
- photolytic processes;
- pyrolytic reactions;
- positive and negative feedback loops;
- modeling;
- gas transport limitation;
- solid-liquid interface.

11. High-power laser applications:

- surface melting and hardening;
- laser welding and cutting;
- laser propulsion;
- laser ignition.

12. Laser micro and nanotechnologies:

- surface cleaning;
- photolithography;
- laser induced phase-transformation, doping and annealing;
- ablative and chemical etching;
- CVD and PVD;
- laser printing;
- microdrilling;
- surface profiling, polishing and structuring;
- bulk structuring;
- laser prototyping.

13. Laser medicine:

- what is biotissue;
- optical diagnostics and tomography;
- phototherapy;
- surgery;
- lithotripsy;
- ophthalmology.