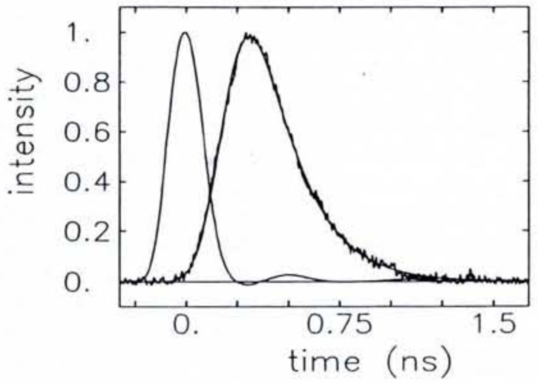
Localization of Light

Analogous to Anderson localization of electrons in disordered conductors, theory predicts that light waves can be localized in disordered media. A group headed by A. Lagendijk at the University of Amsterdam has been studying the propagation of light in disordered media for several years. Actual localization has not yet been demonstrated, but the graph shown here (taken from the thesis of M. van der Mark, 1990) gives evidence that Anderson localization has almost been reached.



The graph records the results of a time-resolved experiment giving the transmission of 5 ps laser pulses at a wavelength in a vacuum of 600 nm through a 165 ± 7 μm thick slab of rutile TiO_2 particles glued together with 1 weight % PMMA. The curve to the left is the measured response as a function of time of a diode to the pulses from the dye laser. The curves to the right are the measured (noisy) transmission curve and the fitted theoretical curve. The localization transition is expected to be given qualitatively by the Ioffe-Regel criterion, *i.e.* when the mean free path equals the wavelength divided by 2π. From the experimental value of the diffusion constant and the estimated refractive index one obtains a mean free path which is 1.86 times larger than the value given by the Ioffe-Regel criterion. This result provides strong evidence that the physicists in Amsterdam have nearly been able to obtain the Anderson localization of light.

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by the government, also carry out physics research. Of these industrial laboratories and institutes, **Philips** and **Shell** employ by far the largest numbers of physicists (about 3000 all told). Private companies spent some 750 million guilders on physics research in The Netherlands in 1987. In the same year, government spending on physics research amounted to 270 million guilders so the bulk of physics research is going on in industry.

The industrial research is of course largely oriented towards R. and D. Philips concentrates heavily on semiconductors, materials and microelectronics. The main fields of interest for Shell are computational physics, hydrodynamics, catalysis and composites. There is clearly a wide gap between fundamental research and R. and D. The industrial giants therefore have relatively little influence on the educational and research systems in the universities. Nonetheless, academic and industrial researchers try to communicate extensively.

Just as two large companies dominate expenditure on physics research at the national level, so too is there a dominant organization in the academic world. It is the Foundation for Fundamental Research on Matter (**FOM**) which provided about 100 million guilders of the total of 270 million guilders spent on academic research in physics in 1987. The balance was made up of the Dutch contribution to CERN and funding of the nine Dutch universities which have physics or applied physics faculties.

There are about 180 university physics professors and each year approximately 450 students complete first degrees in physics and 120 graduates receive Ph.D.'s. The output of Dutch physicists in terms of the number of articles published has been rising over the years and now amounts to just under 2% of the world total. Measured by the citation rate, Dutch physicists rank seventh in the world. Roughly 31% of all articles with Dutch authors are written with colleagues working abroad, signalling that Dutch physics is extremely international in character.

International Cooperation

In a small country like the Netherlands the clever thing to do is to concentrate and coordinate physics research as it becomes more sophisticated, complex, international and inevitably more expensive. By founding FOM as long ago as 1946, the Dutch physics community acquired an organization that could manage "big science" through its institutes. Meanwhile, the universities and FOM both carried out small science.

It was quite natural for FOM to become the Dutch partner in the EURATOM fusion research programme (through the FOM Institute for Plasma Physics, Rijnhuizen). NIKHEF in Amsterdam *via* FOM became the home base for participation in the field of high energy particle physics with CERN and in HERA at DESY in Germany. A joint French-Dutch project in nuclear physics, funded by FOM, involving the construction of the new AGOR cyclotron by KVI, Groningen and In2P3, Orsay, is currently underway (see box on page 160: AGOR Takes Shape). FOM is also a founding member of **JESSI** and has participated in its planning. JESSI stands for the Joint European Sub-Micron Silicon Initiative, an industrial initiative that is supported by European Community and national programmes. Presently in an 18 month start-up phase, it is expected that the DIMES institute in Delft will play a major role in any Dutch research involving JESSI. NIKHEF in the meantime is building a storage ring called AmPS for its linear accelerator MEA. Another interesting development is the creation of the FELIX free electron laser facility at Rijnhuizen which will be used by scientists from a number of different fields based both in The Netherlands and elsewhere.

At a more personal level, university and FOM researchers work closely together in many national projects, take part in European Community programmes, and carry out experiments at the Daresbury synchrotron radiation facility in England and plan to do so at the ESRF in Grenoble, France. Indeed Dutch physicists consider it more-or-less routine to work with colleagues from all over the world.

Planning

One of the initial aims of FOM was to coordinate research at the national level and this led to a well-established system of peer review and national research planning. Planning and cooperation at the national level grew over the years. Areas of big science such as nuclear and high energy physics were