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Efficient Generation of UV Laser Radiation for Plasma Diagnostics

Highly efficient generation of pulsed tuneable UV radiation extends the range of two-photon spectroscopy as a versatile basic diagnostic tool for non-equilibrium plasmas.

Two-photon spectroscopy has proved to be a versatile tool for the quantitative determination of atomic number densities not only in plasma research, but also in industrial process technology, where non-equilibrium plasmas generated by electrical discharges and chemical reactions in hot gases play an important role. For well-grounded understanding of these processes, the spatial distribution and kinetic temperatures of reactive species such as hydrogen, oxygen, or nitrogen have to be measured with sufficient temporal and local resolution. In principle, two-photon spectroscopy is highly suitable for this task. However, exploitation of its full potential requires single-mode pulsed tuneable UV radiation of wavelength between 200 nm and 300 nm with power of some megawatts for a few nanoseconds – specifications which are not yet achieved by commercially available laser systems.

Therefore, PTB has developed a novel concept to generate tuneable UV laser radiation by converting the second and third harmonic of a Nd:YAG laser. Frequency splitting in opto-parametric processes and sum-frequency generation together with multiple use of the third harmonic result in unprecedented efficiency. Based on a commercial laser system, an opto-parametric KTP oscillator and a BBO amplifier pumped by second and third harmonic radiation provide tuneable radiation with wavelengths from 430 nm to 2000 nm. Conversion of this output into UV radiation from 205 nm to 300 nm is then achieved by sum-frequency generation with the residual third harmonic. In this way, 2,5 ns pulses with more than 10 mJ energy and a bandwidth of 300 MHz at 243 nm are obtained from moderate input powers of 25 mJ for the second and 200 mJ for the third harmonic. The high efficiency of the conversion scheme opens the way to employ two-photon spectroscopy as a diagnostic tool also for industrial applications.

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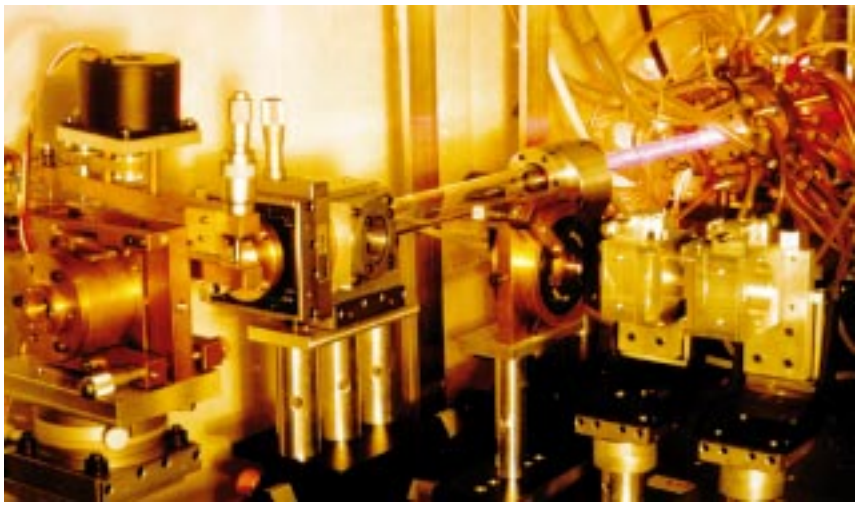

Partial view of a two-photon spectroscopic set-up used to establish a stationary hydrogen arc plasma (upper right corner) as a standard for atomic hydrogen densities

50 Years of PTB-Site Braunschweig

In the beginning of 1947, a presidential committee aiming at the foundation of a new Physikalisch-Technische Anstalt (PTA) as successor institution to the Physikalisch-Technische Reichsanstalt (PTR) was established on Max von Laue's initiative in Göttingen. At the same time, laboratories of the former PTR started to resume their activities at the grounds of a former aviation research institution at Braunschweig-Völkenrode. With these events, the history of the Braunschweig site of the Physikalisch-Technische Bundesanstalt commenced 50 years ago.

Together with chairman von Laue, Werner Heisenberg, Hans Kopfermann and Robert Pohl were members of the presidential committee. Their first goal was to reunite those PTR laboratories which had been evacuated from Berlin to western Germany during the last years of World War II. This «PTR Braunschweig» was put under the control of the economic administration of the joint American and British occupation zones in 1947. As PTA, it became the highest technical authority for measures, weights and calibrations in West Germany one year later. When the Federal Republic of Germany had been founded, the PTA was renamed Physikalisch-Technische Bundesanstalt (PTB) in 1950.

The Braunschweig site of PTB was gradually enlarged to today's 100 hectares, and new

50 Years of PTB-Site Braunschweig
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buildings were constructed to supplement the existing buildings from the thirties. As the most recent new building, the clean-room centre was opened in mid-1993. Today, PTB has a permanent staff of about 1600. Of these, about 1200 work in Braunschweig and about 400 in Berlin.

In western Berlin, another successor institution had developed from PTR after the war, using the old name and reconstructed buildings at the Charlottenburg premises where the Reichsanstalt had been founded in 1887.

The «PTR Berlin» worked in parallel to the PTA/PTB Braunschweig for some years until it became the Berlin Institute of PTB Braunschweig and Berlin in 1953. As the third institution going back to PTR and stemming from laboratories evacuated to Thuringia during the war, the metrology division of the East German agency for standardization, metrology and commodities testing (ASMW) was finally also integrated into PTB as a result of the German reunification in 1990. Thus, PTB comprises all three successors of PTR today and presently has three sites as a result of this historical development: the headquarters in Braunschschweig and the Berlin branches in Charlottenburg and Friedrichshagen. The concentration to Braunschweig and Berlin-Charlottenburg is a target objective of PTB. In order to realize the new structure until the year 2000, the necessary extension of the historic Berlin-Charlottenburg location has been taken up.

PTB celebrated the anniversary of its new beginning 50 years ago with a jubilee weekend in Braunschweig in July 1997. An exhibition was inaugurated which dealt with Hermann von Helmholtz, the great natural scientist and first president of PTR, a Hermann von Helmholtz Symposium was concerned with «Matter and Photon Interferometry» and their metrological applications, and an open day offered interested citizens the oppotunity to find out details about the fields of work of PTB and the services offered by the German national metrology institute.

Aerial view of the Braunschweig site of PTB

Promotion of Metrology in Africa

With a program of technical cooperation projects, PTB promotes individual African countries and especially regional organizations in the field of metrology.

In many African states, metrological activities are limited to basic conventional verification. An exception is the calibration service of South Africa, which has already been capable of signing the multilateral agreement on the equivalence of working procedures and the mutual recognition of certificates of the European co-operation for Accreditation (EA, formerly EAL and EAC). Many other African states need long-term assistance if they intend to set up measuring and testing services which may find international acceptance in the end.

An example of such assistance is a PTB project which supported the establishment of laboratories of the Kenya Bureau of Standards (KEBS) and the training of its staff for many years. As a result, two of the laboratories are soon to be accredited by the German Calibration Service DKD. Another technical cooperation project with the Egyptian National Institute for Standards (NIS) has been completed this year, but further cooperation is ensured by an agreement offering NIS staff members the opportunity of further training at PTB and providing for the link-up of Egyptian standards with PTB standards.

The cooperation with regional metrology organizations is mainly focussed on training in the field of fundamental metrology. Together with the African Regional Standards Organization (ARSO) seated in Nairobi, Kenya, seminars with participants from 10 African countries were held during the past 12 months, and forthcoming scale comparisons were prepared. KEBS supported these activities by making its laboratories and instrumentation available. In addition, quality representatives and quality managers from 12 countries were trained in cooperation with ARSO.

PTB played also an active part in the foundation of the SADCMET metrology organization of the South African Development Cooperation, which is formed by 12 South African states. For members of this organization, two seminars were held recently.

The funds required for these measures were provided by the German Federal Ministry for Economic Cooperation and Development which plans to continue the support for regional metrological organizations in Africa.

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European Petrol Station Interface

The ever increasing networking of complex devices in large petrol stations required standardization of the interfaces. In cooperation with industry, PTB has developed the standardized European Petrol Station Interface (EPSI) which facilitates manufacturing, testing and operation of the installations.

In modern petrol stations, many petrol pumps have to be integrated in computer networks together with an ever increasing number of additional devices and service facilities. Originally, various different technologies and interfaces were employed for these networks. By this, pattern approval tests became more and more difficult. In addition, it became clear about ten years ago, that there was no adequate technology for the growing medium-term requirements on data communication and control which could be foreseen.

On request of the oil industries, PTB took up the development of a future-oriented communication system for the data measured in complex, event-controlled petrol stations. The EPSI project commenced in 1992 with a pilot installation in a Berlin laboratory; with the start of the series production in 1996, it is now successfully completed. The result is based on accepted standards (ISO 8482, MMS) and provides an open industry standard. The German DIN committee «Tank» has begun to elaborate an EPSI standard earlier this year; European standardization is to follow.

As advantages of the new standard, manufacturers will have lower expenses for development and petrol station operators will have a wider choice of equipment. In addition, pattern approval testing will be facilitated for PTB. Procedures for competent testing at low cost were elaborated in cooperation with the conformity testing laboratory at the Technical University of Chemnitz which was established to support the project.

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Presentation of the EPSI bus at the Interkama fair in Düsseldorf

Structures in Laser Fields

Spontaneous structure formation of laser fields was investigated with a view to applications in precision metrology and optical information processing.

Under special circumstances the non-linearity of laser media can lead to chaotic behaviour and to regular or irregular spatial structures of laser fields. For possible novel applications in precision metrology such as the realization of superstable lasers or improved frequency standards based on atoms trapped in structured fields, these phenomena have to be kept under strict control. Spatial solitons which occur due to the balance of diffraction and nonlinearity promise applications in optical parallel information processing.

Financed by the ESPRIT information technologies programme of the EC and organised by PTB, a pilot study towards a parallel soliton matrix processor based on earlier optical structure formation work of PTB has now been completed. PTB has realized such solitons in three different systems for the first time. Arrays with up to twenty solitons were achieved, which could be individually addressed. Experiments have also shown that these solitons can be shifted or localized by field gradients as is required for a matrix processor.

It is expected that the project will be further pursued by six European groups coordinated by PTB in a future ESPRIT project oriented strongly towards the semiconductor micro-implementation.

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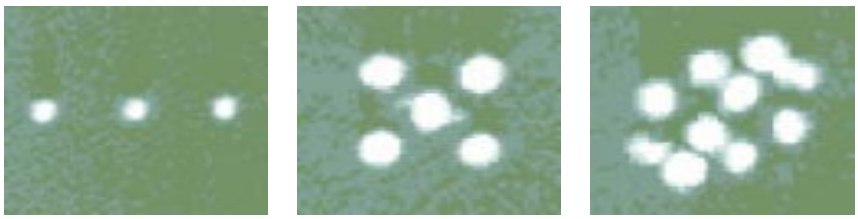

Experimental realization of arrays of three, five, and ten spatial solitons. The solitons have a diameter of 0,1 mm.

20 Years of DKD – 200 DKD Calibration Laboratories

In 1977, the Deutsche Kalibrierdienst (DKD, German Calibration Service) was founded by the Bundesministerium für Wirtschaft (BMWi, Federal Ministry of Economics), the Bundesverband der Deutschen Industrie (BDI, Federal Association of German Industries) and the Physikalisch-Technische Bundesanstalt. Thereby, it became possible to transfer calibration tasks from PTB to private companies.

Company-owned calibration laboratories are accredited by PTB as DKD laboratories for certain measurands and measurement ranges so that they can – for their own purposes or as a service for others – carry out calibrations which are traceable to national standards and the international system of SI units as required by the EN ISO 9000 and EN 45 000 series of European standards. The DKD thus is an early example of successful deregulation and of the strengthening of an important sector of technical and scientific services.

Today, calibration laboratories for many different measurands exist all over Germany. During the DKD anniversary celebrations, Prof. Dr. Kose, vice president of PTB and head of the DKD, presented the accreditation certificate to the 200th DKD laboratory, a calibration laboratory of the German Society of Clinical Chemistry which is the first DKD laboratory in this field of metrology.

The DKD is a member of the European co-operation for Accreditation (EA, formerly EAL and EAC) and is well-accepted as a reliable partner by other countries in and outside Europe. The good reputation of the DKD can also be gauged from the increasing number of renowned metrological laboratories abroad that are accredited as DKD laboratories. Other DKD laboratories will soon be added to those already existing in Europe, the Near East, North and South America, especially in countries which are supported by PTB with technical cooperation projects in developing a metrological infrastructure.

The DKD anniversary was celebrated with a function under the title «DKD: A Contribution to the Technical and Economic Infrastructure in Germany» in Braunschweig on 2 September 1997. Speeches that were given by Klaus Bünger, permanent secretary of the BMWi, Dr. Ludolf von Wartenberg, general secretary and member of the presidential board of the BDI, and Dr. Terry Quinn, director of the Bureau International des Poids et Mesures in Paris, emphasized the importance of the technical and scientific infrastructure for production and services in Germany as a business place and for international trade relations. With its weighty contribution to this infrastructure, the DKD also contributes to ensuring the competitiveness of German industry.

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DKD calibration laboratories in Germany
red: laboratories in large-scale enterprises
black: in small and medium-scale enterprises
green: other laboratories (universities, TÜV technical control board, technical state authorities etc.)

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Announcement of 1999 Helmholtz Awards

Hermann von Helmholtz (1821–1894), the eminent natural scientist and first president of PTR

In order to promote research in the areas of activity of PTB, the Helmholtz-Fonds offers three prizes to be awarded in 1999.

The Helmholtz-Fonds was founded by the members of the advisory committee of the Physikalisch-Technische Reichsanstalt in 1913; among its founders were Albert Einstein, Carl v. Linde, Max Planck, Walter Nernst, Wilhelm Conrad Röntgen, and Wilhelm Wien. The Fonds is a private non-profit organization which uses membership fees and donations to promote research and development in the fields of work dealt with by PTB.

Every two or three years since 1973, the Helmholtz-Fonds offered the Helmholtz prize, which was expanded to three prizes in 1987. In 1999, the three prizes are to be awarded in the three fields of

- precision measurement of physical quantities
- metrology in medicine and environmental protection
- informatics and mathematics applied to metrology.

In addition to a certificate, each of the prizes is endowed with DM 10 000. The prizes will be awarded by an independent jury. In order to participate in the competition, a manuscript with five copies has to be submitted not later than 15 September 1998.

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