MY FIRST ENCOUNTER WITH SYNCHROTRON. 34 YEARS AGO

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Synchrotron radiation?

It was already 34 years ago when I got aware of its existence for the first time!

It was the beginning of 1985. In my pigeon hole, at the Jagiellonian University Institute of Physics there was a letter from my good colleague, Leszek Frasiński, a former assistant in the Department of Atomic Optics in the Institute. Then, he had been working for the last few years for the Atomic and Molecular Spectroscopy Group at University of Reading (UK). In the letter he very strongly persuaded me to apply for a post doc position in Reading. It was all about participating in a very interesting, in his opinion, research project regarding molecular spectroscopy using synchrotron radiation. The head of the group was Prof. Keith Codling, which had pioneered synchrotron radiation based research, fully appreciating its research potential from the very beginning [1]

I must admit that those days my knowledge of the subject was none. Synchrotron radiation? Synchrotron means accelerator. What it has got to do with molecular spectroscopy was boggling my mind. Is it about collisions? Electron- molecule? For sure this can not be the case!

Nowadays, the first reaction would be to type *synchrotron radiation* into a web search engine. One immediately gets hundred thousands hits! However, that time, hard to believe, there was no internet! It was up to many hours in library, browsing through abstracts. There was not so many of them though. This was followed by telephone calls to Reading (via operator, after many hours of waiting) and conversations with Leszek. Some requested literature arrived by mail (not email!). After few weeks came the decision time.

I decided to go for it. I was convinced: this must be a very exciting project full of many challenges in diverse fields. Already advanced talks with University of Stirling about a post doc position connected with some conventional high resolution optical spectroscopy had to be abandoned.

Going abroad those days meant loads of formalities, young readers are not aware of. It had to start, of course with the passport application, submitting all variety of forms in Jagiellonian University SB (Secret Police) office. Will they accept the application or will they not?

After few weeks of apprehensive waiting – yes, passport was ready for collection! Now time for a trip to Warsaw to visit UK embassy and for an interview with a UK immigration officer in order apply for visa (hopefully a multi-entry one) and work permit. After queuing long hours from early dawn eventually came a rather unpleasant and comprehensive grilling. Questions about membership to any political parties or organization, financial status, properties, personal situation, children, parents etc. Rather revolting experience, not far away from interrogations by Polish SB. Apparently nothing suspicious emerged and I was judged as an individual who was not threatening the security of the United Kingdom of Great Britain and Northern Ireland. After few weeks I was able to collect all the required stamps and documents. Eventually, at the beginning of September 1985 I was ready for take off to commence my duties at University in Reading. One more thing to do – go and buy from a bank 10 USD with a special, very generous exchange rate—a special allowance for Polish citizens going abroad those days!

On the 1st of October 1985 I took a seat on a Polish Airlines LOT flight from Kraków to Heathrow. From there I took a bus to Reading, only 60 km (40 miles I should rather say!) west from Heathrow. There I was, looking forward to the new chapter in my career. Next day, a morning meeting was planned at J.J. Thomson (1906 Nobel Prize in Physics for discovery of electron) Physical Laboratory. All members of the Atomic and Molecular Spectroscopy Group were present: Keith Codling, Leszek Frasiński, Kevin Randall and Paul Hatherly.

The title of our project was: “Coincidence studies of molecular ions fragmentation using synchrotron radiation”. A sharp start was needed, timing was very tight. In the first four months we had to design and construct the devoted experimental setup (entire experimental station) and design from scratch a data acquisition system together with developing the relevant software. We needed to divide the work. I was eager to be in charge of the latter task. Electronics had been always my hobby and in the eighties PC computers joined the game. Leszek, Kevin and Paul took on the design and construction of the experimental setup: vacuum chamber, time of flight analyzers, micro channel detectors. This was definitely a big challenge time – for all of us. Many aspects of the tasks were new areas for all of us, including Keith.

Accordingly with the assignment, next day I unpacked a brand new IBM AT PC computer with EGA (Enhanced Graphics Adapter—16 colours, 640×350 pixels) graphics card and corresponding colour monitor. I remember its serial number: 0011. Other parameters of the machine: CPU clock: 8 MHz, hard dick capacity:

20 MB, RAM memory: 624 kB. For the first time in my life I switched on a PC. Armoured with a Fortran compiler and Basic interpreter.

It was a thrill indeed! Those days, in Poland, the IT technology was represented mostly in the shape of Sir Sinclair's ZX Spectrums (8 bit processor, few kB of RAM). Sporadically one was able to see a Neptun – Polish clone of Commodore PET (another 8 bit machine). These small machines, developed for the consumer market were used in Polish research environment for computational purposes and also some relatively efficient data acquisition systems were designed utilising these 'machines', painfully interfacing them with hardware. IBM PC XTs in 'advanced' configuration with 10 MB hard disk equipped with DOS or CP/M operating system were just coming to Poland and were subjects of great admiration.

My AT was supposed to be the heart of the data acquisition system of our experiment. The task was to communicate with a CAMAC crate equipped with Autonomous Logic and Arithmetic Unit, memory, a time to digital converter and numerous auxiliary and interfacing modules.

The goal was to have the acquired coincidences displayed in real time as a false colour map. The first big problem came rather fast: tests revealed that it took minutes to display such a 256×256 map (65536 individual pixels) using the purchased Fortran graphics library. For me that meant programming the graphics card in assembler, if I was lucky. If not it meant using the machine code. Which was going to be the case anyway to communicate with the CAMAC controller. Some good fun was ahead! The colleagues could not complain about lack of work either. The experimental setup was quite complicated, equipped wit rotatable double time-of-flight analyzers. Everything needed to be built from scratch and experience was needed in designing the detector setups and high vacuum hardware and instrumentation. Our technician was also giving all his best to manage to machine all the bits and pieces in time.

Those days, in Kraków vacuum chambers were built mostly of glass. This meant outgassing the Apiezon greased glass valves and continuous fight with small leaks. Diffusion pumps were used with all the associated problems (presence of hydrocarbons, oil burning *etc*.). Vacuum conditioning lasted for days and weeks. The glass blowing technician was the person to be in very good relation with!

There we had to produce a high vacuum chamber, free of hydrocarbons to be able to connect it to the synchrotron source termination. Forget glass, Apiezon, diffusion pumps *etc*. New vacuum culture had to be applied: stainless steel chamber and fittings, turbo molecular pumps, KF and CF fittings and flanges. 10^{-7} torr vacuum achievable in few hours. All new technology - quite a step forward.

That autumn and even the Christmas period was a very busy time for all of us; hard work. In January we were almost ready. Came the last time for tests and modifications. The acquisition system eventually seemed to be working: collecting and displaying in real time the data from a home built multi-coincidence simulating generator. However, something was wrong: there were very annoying intermittent problems. The communication between the CAMAC controller and the PC sporadically got lost. This certainly was not good and made me frustrated. However, as sometimes happens, after few days of furious tests the problem got resolved by sheer accident. It was just a 5 m long, multi wire ribbon cable connecting the PC with CAMAC, which was causing problems. But it was not as trivial as its contacts. It was just when it was nicely arranged in a tidy roll when apparently some crosstalk between the signals was scrambling the communication. An interesting lesson of applied electronics: keep the cables untidy!

Vacuum chamber was also ready, the two time of flight analyzers and the detectors tested. Our experimental session was planned in few weeks time at Daresbury Laboratory Synchrotron Radiation Source – the *second generation* UK synchrotron radiation facility – *e.g.* designed and built solely as a source of synchrotron radiation, mostly from bending magnets.

Eventually the time has come. We hired a van and after filling it up with all the equipment we took off to Daresbury. Daresbury is a small village (few houses, a church and of course a pub) in the north of England, near Manchester and Liverpool. On my way there I learned that it is known not only because of the synchrotron facility there but because the author of "Alice's Adventures in Wonderland", Lewis Carroll was born there. However his true name was Charles Lutwidge Dodgson and his principal job was lecturing mathematics at Christ Church College in Oxford in the second half of the XIX century. Apparently the place was special and we were going to a wonderland!

The team appeared to be relaxed, however the prospect of using such a unique source of radiation and working in the large scale facility environment increased my adrenaline level for sure. Above all, I am a researcher and an experimentalist hence I bound to be excited!

We drove very carefully. Such a fragile load needed special care. We did not want the detectors to crack from the vibration. Or any connections got loose inside the vacuum chamber. Eventually we arrived to Daresbury in the evening. It took us some hours to unload and wheel the equipment to the beamline (no. 3.11 – Seya monochromator). When we finished it was time to go straight to bed in a small hostel for the users run by Daresbury Laboratory. Next day morning we were welcomed with typical English breakfast with toasts, fried eggs, sausages and baked beans. It made a perfect introduction into our first session at Daresbury. So it has started. Next month we spent on conquering our experiment, getting known all the control subtleties of our beamline and the monochromator, learning the storage ring refilling procedures; working 20 hours per day. The synchrotron crew had also their share of problems and challenges to provide a stable operation in a single bunch mode, which was required for our experiment in order to ionize oxygen molecules by a everything one day everything was ready, the equipment was fine tuned, stable single bunch stored in the ring – and we started the real measurement! We were acquiring coincidences between photons, electrons and ions! We were watching, point after point, how our dreamt of colour map of coincidences between the exciting light pulse, photoelectron and photoion in the time of flight (momentum) domain was built up in real time.

Everything was going as we planned – emerging map illustrated energy levels in molecular oxygen – in colour (Fig.1)! A wonderland indeed!

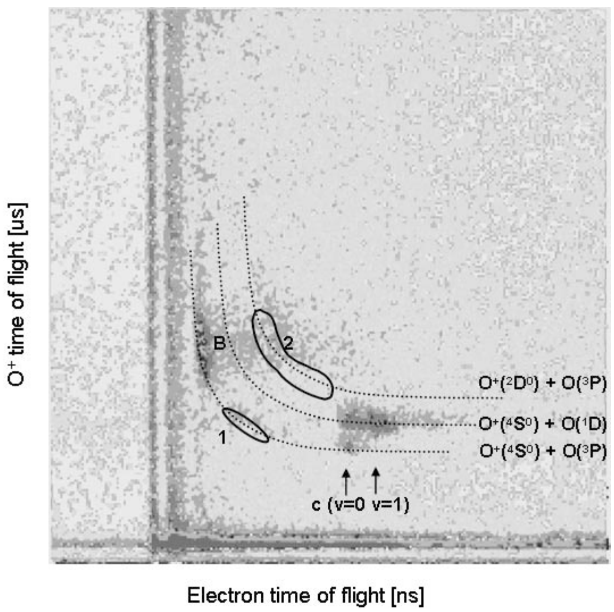

Figure 1. Electron-ion coincidences in ionization of O_2 at 486 Å (25.5 eV). Coincidence features: B, predissociation of the B $^2\Sigma_g^-$ state to $O^+(^4S^0) + O(^3P)$; *c*, *v* = 0 and *v* = 1, predissociation of the c $^4\Sigma_u^-$ state to the limits $O^+(^4S^0) + O(^3P)$ and $O^+(^4S^0) + O(^1D)$; 1, repulsive state to the limit $O^+(^4S^0) + O(^3P)$; 2, repulsive state III $^2\Pi_u$ to the limit $O^+(^2D^0) + O(^3P)$. The horizontal line is due to cross-talk; the vertical lines are due to false coincidences. Taken from Ref. [2].

Of course, that day we had to celebrate this success in the nearby, very popular (ask any of the Daresbury Laboratory users!) "Ring'o'Bells" pub with "a pint or two" of a decent English ale.

This is how my adventure with synchrotron radiation based research has started. Since then, for the last 34 years, my research activities have been focused closely on investigation of molecular processes excited by synchrotron radiation.

The Daresbury Synchrotron Radiation Source ceased its operation last year. UK research community has now a new, advanced *third generation* synchrotron source – "Diamond" available.

Nowadays I commute from Kraków mostly to *MAX-lab* in Lund and to *Sincrotrone Elettra* in Trieste, where I have met a very friendly environment. Keith Codling has retired. Leszek Frasiński holds professorship at Imperial College in London, Paul Hatherly works for Open University in Milton Keynes (England-Buckinghamshire) and the last place where I localized Kevin Randall was Advanced Light Source in Berkeley (California, USA). We are all still around synchrotrons. I am sure that we all remember the period of our first project at Daresbury as a very special one.

From that time the spectrum of synchrotron radiation users has immensely broadened. Nowadays physicists are just one of many groups representing diverse fields of research done at synchrotron radiation facilities. Investigations are carried out, amongst others, in such fields as medicine, biology, chemistry, material science, archaeology etc. Much has changed in the field of electronics, IT technology, and vacuum generation. There has been a big progress in synchrotron design and associated instrumentation, focused on optimizing the radiation output. There are many companies providing synchrotron specific instrumentation which spun off from relevant research projects. Many new synchrotron radiation facilities have been built all around the world. Availability of these unique sources of radiation allows thousands of researchers from different fields for performing experiments otherwise impossible. New, *fourth generation* sources – *Free Electron Lasers* are the latest challenge in the field. Some such facilities are already operating (*e.g. FLASH*, *TESLA* in Europe) another being constructed (*FERMI*), opening new horizons in science.

I am writing these memories when there are strong initiatives to build in Poland a synchrotron radiation source and a free electron laser. I wish that one day in the nearest future at least one of these initiatives is going to be successful. I am convinced that this would be a great day. I am sure about the immense benefits which these projects could bring to the Polish research and education community.

Acknowledgements: I would like to thank Prof. Wojciech Paszkowicz for inviting me to write these memories. I mostly appreciate his initiative.

References: I have decided to refer only to two publications. Anyone interested in whichever aspect of synchrotron radiation is strongly encouraged to visit http://www.lightsources.org/cms/ where there is a copious amount of information available.

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[2] J. Frasinski, M. Stankiewicz, K. Randall, P. Hatherly, K. Codling, "Dissociative photoionisation of molecules probed by triple coincidence; double time of flight techniques", *J. Phys. B: Atom. Mol. Opt. Phys.* **19** (1986) L819–L824..

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Swiss Light Source Solutions for Industry with Synchrotron Light Gabriel Aeppli, Head of Synchrotron Radiation and Nanotechnology, Paul Scherrer Institute Â«The Paul Scherrer Institute is Switzerland's largest national laboratory for engineering and natural sciences, and we strongly welcome industry to make use of our research facilities, either directly, or in partnership with university research teams.Â Scherrer Institute has been supporting partnerships between the Swiss Light Source and industry for many years. â€¢ On-site guest house and restaurants for use during experiments Swiss Light Source :: Solutions for Industry with Synchrotron Light 13 Technical references What is the nanostructure of a coated porous glass? Synchrotron emission from such a small vw would be extremely dicult to detect. Star S2 is massive, and thus the winds are likely an order of magni-tude larger.Â Figure 1. Non-thermal synchrotron power and ux compared with emission from Sgr A* (data for Sgr A* was obtained from. Yuan & Narayan 2014). The left panel shows the dependence of the synchrotron emission on wind mass loss rate. More than 5000 researchers a year use Synchrotron instruments. Each beamline requires a cabin space for scientists to operate the beamline, run their experiments, analyse data and prepare experimental samples. ANSTO plans to increase this capacity over the next eight years.Â â€œSynchrotron scientists and engineers were engaged in the design process through user interviews, observation and prototype testing. Itâ€™s an exciting first project in our partnership. We are planning our next collaboration with ANSTO Synchrotron,â€ explains Ms Tuulos. The DFM ANSTO partnership draws inspiration from IdeaSquare, a Design Factory platform at CERN, that accelerates ideas through collaboration and experimental innovation. A synchrotron is a particular type of cyclic particle accelerator, descended from the cyclotron, in which the accelerating particle beam travels around a fixed closed-loop path. The magnetic field which bends the particle beam into its closed path increases with time during the accelerating process, being synchronized to the increasing kinetic energy of the particles. The synchrotron is one of the first accelerator concepts to enable the construction of large-scale facilities, since bending, beam...