Research Stay in Japan in Spring/Summer 2014

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Preamble. In 2014 I was most happy to be awarded a research fellowship by the Japan Society for the Promotion of Science (JSPS) in cooperation with the Deutsche Akademische Austauschdienst (DAAD). During my stay between May and July 2014, I had the opportunity to visit several research institutes and universities in Japan. Among these were the Research Reactor Institute at Kumatori campus and the Yoshida campus at Kyoto University, the Institute for Materials Research of Tohoku University, the Applied Physics Department at University of Tsukuba as well as laboratories at AIST and KEK in Tsukuba, the Department of Applied Chemistry at Chiba University, laboratories at Tokyo University of Science and the University of Tokyo.

At these institutes, I was invited to give scientific talks and lectures covering a broad field in positron research. Within these talks the following topics have been addressed: the generation of high intensity positron beams, gamma-beam induced pair production, defect spectroscopy using positron annihilation techniques, determination of the electronic structure, polarized positrons, surface studies using PAES, Positronium, high precision measurement on Ps^-, positron electron plasma experiments, as well as neutron experiments and a general overview about research and education at TUM. Within very fruitful discussions together with the Japanese colleagues we focused on various scientific topics in the current research using positrons and complementary techniques as well as future developments. In this way, a large variety of topics in the field of physics with positrons ranging from fundamental experiments to current applications in materials science have been addressed.

Kyoto University. During my stay at the Kyoto University Research Reactor Institute (KURRI) Prof. Xu showed me the interior of the reactor and the connected experiments as well as other facilities at the Kumatori campus. Then we focused on the new reactor based positron source and the positron beam facility. We discussed several aspects such as shielding against gamma and neutron radiation, positron beam transport, bunching system, the sample chamber and the detectors. Together with Prof. Yoshiie I visited the Fixed Field Alternating Gradient (FFAG) facility where he presented very recent proton irradiation experiments. At several meetings we discussed the current status of the KUR reactor as well as science using research reactors in general. Dr. Sato presented the lay-out and first impressive experimental results of the reactor based positron source at KUR. In particular, we discussed next steps to further improve the positron facility such as a cooling system, geometry of the source, parameters of the magnetic field for positron extraction, and compensation of curvature drifts.

At the Yoshida campus in Kyoto University, several issues in surface science and solid state physics such as surface segregation, positron interaction in matter, and precipitation in metals were elucidated in detail during a fruitful discussion with Prof. Shirai. At a guided tour through his labs, I had the opportunity to see several positron lifetime spectrometers using the gamma-gamma coincidence technique with digital read-out, the beta-gamma coincidence setup using a thin APD start detector and a Ge-68 positron source as well as the very compact lifetime spectrometer for inspection of larger specimens.

Tohoku University. In a joint project of TUM and Tohoku University complementary techniques are applied in order to investigate the homogeneity and possible impurity atoms in bulk and thin film samples of FePt which is a promising materials for future high-density magnetic storage devices. Within the stay in the group of Prof. Nagai we performed experiments using a focussed ion beam (FIB) for sample preparation as well as electron microscopy (SEM) and 3D-atom probe (ATP) for sample characterization. The 3D-atom probe provided 3D information of the elemental distribution of the bulk. Different positron spectrometers were used in order to study the open-volume defects and their chemical surrounding on an atomic scale. For this purpose we applied (non-destructive) positron annihilation lifetime spectroscopy (PALS) and coincident Doppler broadening spectroscopy (CDBS). We succeeded in finishing the measurement of different as-received and annealed alloys and discussed the results and the details of the data analysis. The data analysis and further measurements of reference samples are still in progress. The obtained results will be compared with depth dependent (C)DBS measurements at NEPOMUC at TUM.

University of Tsukuba, AIST, and KEK. Prof. Uedono gave me an overview about the organisation and the structure of both University of Tsukuba and the science city of Tsukuba. In his institute he showed me the positron experiments for

the investigation of atomic defects in semiconductors. The type and the role of atomic defects leading to a degradation of nitride based semiconducting devices will be studied in a joint effort of the NEPOMUC group at TUM and University of Tsukuba. For this reason, we discussed the joint project of both research groups in order to investigate the defect-related properties in thin film semiconductors. In particular, we focused on new experiments on thin semiconducting films at NEPOMUC, which are planned to be performed in 2014.

Thanks to Prof. Uedono's organisation I could visit various scientific institutes in different fields of physics. I could get an impression of the forefront in semiconductor research at the National Institute for Materials Science (NIMS). In addition, we applied photoluminescence measurements on selected semiconducting thin films as complementary technique for defect characterization. At the Plasma Research Center at University of Tsukuba I had the opportunity to visit the worlds largest tandem mirror machine GAMMA 10 for fusion science. Prof. Ichimura showed me the experimental hall and explained several aspects of the confinement improvement via plasma electric potential and magnetic fields as well as various tools for plasma diagnostics and devices for plasma heating. At the University of Tsukuba Tandem Accelerator Complex (UTTAC) Prof. Kimikazu Sasa lead me through the different experimental halls and explained on-going works in setting up a new tandem accelerator. I also had the chance to have a look in the tank of the pelletron accelerator destroyed by the earthquake in March 2011. We also discussed different experiments such as cluster ion beams, Rutherford backscattering and elastic recoil detection.

I also spent time at the National Institute of Advanced Industrial Science and Technology (AIST) where I gained a great overview of ongoing studies in basic and applied physical research. In a first team meeting Prof. Suzuki presented recent progress in new miniaturized radiation dosemeters and a newly developed mini X-ray source. I could gaze at both devices during operation. At the linear accelerator facilities Dr. Oshima and colleagues presented different converters for positron production. He showed me the micro probe analyser, pulsing devices and the positron transport system. In particular, we discussed the brightness enhancement using positron remoderators. Dr. O'Rourke presented the current status of the superconducting linac for future positron production. With the responsible scientists at the different experiments I discussed the development of e.g. the production of positrons using Compton backscattering, gamma induced positron annihilation studies as well as high-sensitive surface studies. In the group of Dr. Ito I had also a look on pulsed beams and a commercial positron beam apparatus.

Prof. Toshio Hyodo and colleagues gave a guided tour through the accelerator facility at KEK. There I could see the linac dedicated for positron beam experiments with its remoderation stage using the 35 keV positron beam. They presented the spectrometers for positron surface diffraction and the photo-detachment of the Positronium negative ion. We discussed in detail the benefit from high brightness positron beams using total reflexion for high-sensitive surface measurements. Furthermore, we talked about developments at large scale facilities in order to generate positron beams of highest intensity.

Chiba University. At Chiba University Prof. Fujinami presented the positron laboratory, where I could get an impression of the tabletop monoenergetic positron beam. On site we discussed the performance of the system and different optical elements for beam transport, deflection and focussing. He explained several technical constraints for the realization of the magnetic lenses. Furthermore, we discussed the development of novel devices for brightness enhancement in order to generate new positron beams with μm spot size. We also talked about essential properties such as handling, high temperature annealing and surface cleaning of thin single crystalline foils. He also presented several state-of-the-art lifetime and Doppler-broadening spectrometers using ^{22}Na as positron source. Together with students we discussed their recent results on plastically deformed metal samples with and without hydrogen loading.

In addition, members of Prof. Fujinami's research group introduced me in their experiments on tip-enhanced Raman spectroscopy for the investigation of biomolecules, and quasi-elastic laser scattering techniques for the determination of surface tension in liquid phases. We discussed in detail fundamental aspects such as energy conservation and driving forces in order to elucidate the experimental results.

Tokyo University of Science and Tokyo University. At the Tokyo University of Science, I visited the research group of Prof. Nagashima. In his labs, he presented the impressive experimental setup for the production of the Positronium negative ion (Ps^-) and photo detachment experiment. We discussed current fundamental experiments focused on the efficient production of Ps^-, and the excitation and photo-detachment experiments on this bound leptonic system. In addition, further experimental improvements and future projects such as the generation of a monoenergetic Positronium beam were discussed in detail.

The final highlight of my stay was the invitation to the meeting of the Japanese positron society at the University of Tokyo. There I presented recent experiments using positron beams and polarized positrons carried out in our research group at TUM.

Summary. During my stay, I gained the impression that most Japanese research groups perform experimental and theoretical studies at the forefront of research in the field of physics with positrons. Fortunately, there are a high number of professorships and hence many different research groups in solid state physics, materials science, atomic physics and chemistry using positron techniques. The instruments I was introduced to are of the top level. In addition, a great variety of positron experiments are being further developed for novel applications. The discussions at the different institutes were always very fruitful due to the lively atmosphere which I have experienced.

Besides the research activities I seized the opportunity to visit historic sites of Japanese culture such as Kamakura (together with Prof. Yasuyoshi Nagai and family) and Nikko. During a sightseeing tour, I also visited various interesting places in Tokyo. In addition, natural highlights have been a tour to Mount Fuji (together with Prof. Masanori Fujinami and students) and the Fukuroda waterfalls. At weekends too, my hosts were very open and contacted me e.g. for a sightseeing tour or for dinner.

In general, Japanese people are known to be extremely friendly and helpful. According to the experience I gained during my stay, I can fully confirm their excellent hospitality. My Japanese colleagues as well as most people I met were very helpful every time.

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ほんとうに，どうもありがとうございました．

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