Widely tunable laser system for laser irradiated pump-probe type μSR experiments at RIKEN-RAL

P. Bakule[1], Y. Matsuda[1,*], H.W.K. Tom[2], K. Yokoyama[2], E. Torikai[3], K. Shimomura[4], F.L. Pratt[5] and K. Nagamine[2,4]

[1]*Advanced Meson Science Laboratory, RIKEN, Wako, Saitama 351-0198, Japan*
[2]*Department of Physics & Astronomy, University of California, Riverside, California 92521, USA*
[3]*Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Kofu, Yamanashi, 400-8511, Japan*
[4]*Muon Science Laboratory, High Energy Accelerator Research Organization, Tsukuba, Ibaraki 305-0801*
[5]*ISIS, Rutherford Appleton Laboratory, Chilton, Oxon OX11 0QX, UK*

An ideal match of Q-switched lasers (1-200 ns pulse duration) with pulsed muon sources (100 ns pulse duration) has so far been scarcely utilized in muon experiments. Yet, sample irradiation with tunable laser pulses synchronized with muon implantation provides an extremely useful tool that extends the scope of μSR spectroscopy. Depending on the photon energy, the laser irradiation will cause coherent electron excitation or ionization in the studied sample or even affect the muonium state directly (e.g. convert diamagnetic Mu^- state to paramagnetic Mu). Additionally, circularly polarized light can induce spin polarization of the excited electrons in the sample. The effects of the pump laser pulse on the sample can then be sensitively probed using μSR technique. The time difference between the muon implantation and the laser irradiation can be easily controlled on a nanosecond scale and such pump-probe experiments can then also provide measurement of the decay time constant of the generated excitation.

To allow routine use of such pump-probe technique we have build a dedicated laser room and laser beam delivery system next to the ARGUS μSR spectrometer at RIKEN RAL muon facility. The installed laser system is based on an optical parametric oscillator (Continuum Panther EX OPO) pumped by a Nd:YAG laser (Continuum Powerlite 9025). The pulse duration is 8 ns FWHM with 25 Hz repetition rate, which is an optimum for ISIS running at 50 Hz repetition rate. This system offers a very wide tuning range of 400-2500 nm (photon energy of 0.5-3.1 eV) which can be extended to UV wavelengths as low as 200 nm (6.2 eV). The pulse energies are in the range of 1-70 mJ, while typical energies required for sample excitation are below 1 mJ/cm^2. The laser output is linearly polarized, but we have also built an optical setup for sample irradiation with left-hand and right-hand circularly polarized light including pulse-to-pulse control of the polarization. We are currently working on extending the computer control of the wavelength, pulse energy and timing so that the laser parameters can be changed in a user friendly manner consistent with the control of other experimental parameters such as magnetic field or sample temperature.

The pulses from this highly flexible laser system are steered to the sample position through a light-tight beam delivery system using broadband HR mirrors (R>99% over 350-1150 nm), some of which can be remotely controlled. Beam position on the sample is monitored using FireWire cameras. Samples are typically mounted in a vacuum chamber on mini-cryostat capable of reaching temperatures of about 15 K. Different mirror and sample configurations are possible. Either the front or rear surface of the sample can be irradiated. All necessary services are also available for installation of another custom laser system within the laser room.

[*)] *Present address: Graduate School of Arts and Science, University of Tokyo, 3-8-1 Komaba, Tokyo 153-8902, Japan*