Spin oscillations in radical ion pairs: from nanosecond to picosecond time domain

O.A. Anisimov*, B.A. Knyazev#$, A.N. Matveenko#$, and Y.N. Molin*

* Institute of Chemical Kinetics and Combustion SB RAS, 630090 Novosibirsk, Russia. Phone: +7 383 333 1607, fax: +7 383 330 7350, e-mail: molin@ns.kinetics.nsc.ru
# Budker Institute of Nuclear Physics SB RAS, 630090 Novosibirsk, Russia. Phone: +7 383 339 4859, fax: +7 383 330 7163, e-mail: A.N.Matveenko@inp.nsk.su
$Novosibirsk State University, 630090 Novosibirsk, Russia. Phone: +7 383 339 7805, fax: +7 383 339 7807, e-mail: knyazev@phys.nsu.ru

Singlet-correlated radical ion pairs produced in solutions by pulsed irradiation are known to oscillate between their singlet and triplet states. The oscillations can be readily observed by monitoring the fluorescence from singlet excited molecules arising from ion pair recombination. The frequency of oscillations depends on the strength of the external magnetic field and is a function of hyperfine coupling constants and g-value difference of the recombining radical ions. The detection of spin oscillations provides valuable information on the ESR spectra, spin relaxation times and reactions of short lived radical ions, which are not observable by ESR techniques1,2.

The time resolution of about 2ns is limited for the available setup by the duration of the X-ray pulse. To observe oscillations with shorter periods and/or to detect radical ions with subnanosecond lifetimes, one needs much better time resolution.

The new setup is now under assembling. For pulse irradiation, the electron accelerator of free electron laser3 is to be used. The pulse duration is 70 ps, the maximum repetition rate is 22.5 MHz, the electron energy is 12 MeV and the maximum average current is 20 mA.

The copper target is used to convert the electron beam to X-ray beam that is used for sample ionization. The distance between the target and the sample is about 1 m. The same distance (in perpendicular direction) is between the sample and photomultiplier. The sample is placed between the poles of electromagnet that can provide magnetic field strength up to 1.8 Tesla. The fluorescence from the sample is collected with quartz collimator that is placed between the sample and the photomultiplier. High speed photomultiplier detector head PMH-100-6 (Becker & Hickl) for photon counting is used for registration of time dependence of fluorescence intensity with time resolution 180 ps. It is placed in a box shielded with steel and lead against electromagnetic interference and ionization radiation. The signals from detector head go to “stop” input of time-to-digital converter whose “start” input is connected to the synchronizing generator of the accelerator. The output of time-to-digital converter is connected to computer terminal.

The start-up of the setup is expected in spring of 2005.