The He Spin-Echo technique comes of age: The search for answers to the complexity revealed through surface dynamics measurements

The technique of Helium spin echo (HeSE) is now well established as a probe of atomic length and timescale dynamics at surfaces and its power in elucidating the details of atomic motion has been shown on a wide range of systems. This body of data has revealed a series of fundamental questions not just about surface dynamics but also about the wider concepts of rate processes, and now, as well as the ongoing use of HeSE as a probe of the dynamics of key systems, we can focus on addressing these central issues. Key questions include:

(1) When does classical mechanics suffice in modelling atomic scale dynamics.
(2) How many degrees of freedom of the moving species do you need to include to model the dynamics from first principles
(3) STM and HeSe data can be used to probe the same thermally activated process over 15 orders of magnitude rate change: how do you explain the fact that both Arrhenius and non Arrhenius behaviour is seen in these extreme tests of rate theory
(4) Is the motion of an adsorbate sensitive to the 'noise spectrum' of the heat bath: do we care if the noise is pink or white.
(5) How can a dynamical system have 'memory' that extends beyond the slowest feasible phonon processes.
(6) To what extent can truly first principles calculations be performed of the measured quantum propagation (*e.g*. H ground state to ground state tunnelling) connected to a heat bath (surface free electrons/phonons) – *i.e*. the 'decoherence/dephasing' question.

In support of these aims opportunity has been taken to upgrade the resolution (3x), degree of polarisation and sensitivity of the instrument, to enable the boundaries of the measurement space to be significantly extended.