Scanned Spin Noise Microscope

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In association with Andrew Mackenzie, Seamus Davis proposes to create and deploy a nm-resolution scanned spin noise microscope ***SSNM***. This unique instrument will connect a nm-scale superconducting input-coil to a DC-SQUID, thus allowing measurement of the time dependence of magnetic flux $\Phi(t)$ or the flux-noise spectral density $S_{\Phi}(\omega, T)$ with high spatial resolution. To achieve this objective, we propose to micro-fabricate the pickup coil in a scanned-tip geometry by using focused ion beams (FIB) at the MPI in Dresden. The first-generation pickup coils will then have sub-micron-scale resolution and to plan increased the bandwidth of $S_{\Phi}(\omega, T)$ of the ***SSNM*** to about 2GHz, using an advanced SQUID.

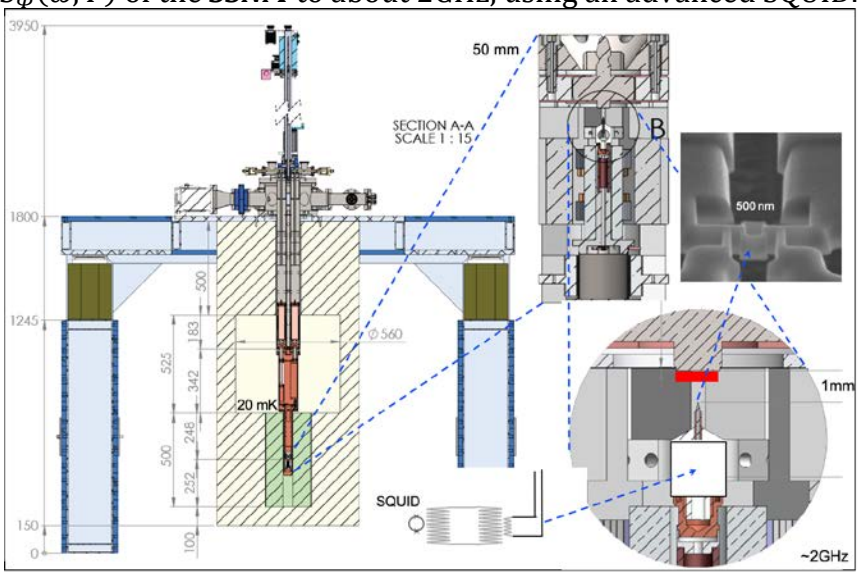

Fig. 3 The schematic design of the MPGCQM SNNM microscope.

Our experimental objectives for ***SSNM*** include:

a) We will use ***SSNM*** to visualize the magnetic monopole fluids in $Dy_2Ti_2O_7$ and $Hio_2Ti_2O_7$ as a function disorder, temperature and eventually magnetic field. Below T=250mK the monopoles freeze, and ***SSNM*** will image their conformation to determine if they are constrained by a spaghetti of Dirac-strings connecting each magnetic-charge pair.

b) Both $ZnCu_3(OH)_6Cl_2$ and $YbMgGaO_4$ are famous candidate materials in which QSL states may occur. However, the former may be magnetically disordered merely due to impurity spins from inter-substitution of Cu at the Zn site, thus mimicking a QSL. A similar situation may pertain in $YbMgGaO_4$ due to inter-substitution of Mn for Ga. Thus, what is urgently needed is imaging of spin excitations in these QSL candidates by ***SSNM*** to reveal their nanoscale heterogeneity or homogeneity. If either is a viable QSL, its fingerprint in the spectral density of spin-noise $S_{\Phi}(\omega T)$ will be compared to microscopic QSL theory.

c) Magnetic skyrmions are nanometer scale vortices in the texture of spins occurring in magnetic insulators e.g. $Co_7Zn_7Mn_6$. We plan is to image the flux-noise $S_{\Phi}(\omega T)$ of dynamical skyrmions by ***SSNM***, in glassy and especially liquid phases, or while undergoing collective transport, and thus to establish transport theory for skyrmion fluids.