Supplementary infomation for:

Molecular spin echoes; multiple magnetic coherences in molecule surface scattering experiments.

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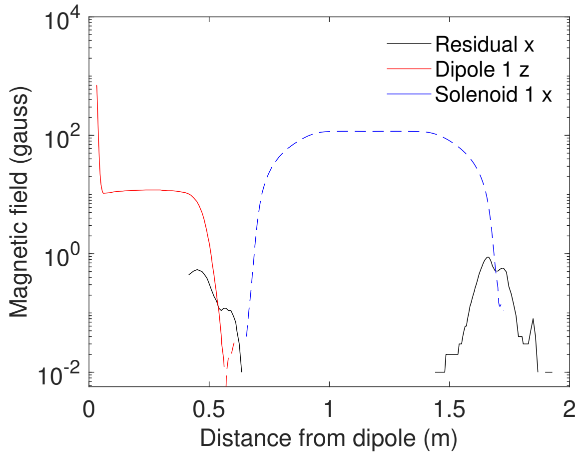

FIG. 1: The magnetic field profile for the first arm of the machine. Positive fields (with respect to the x and z axes) are shown as solid lines, and negative fields as dashed lines. There are no fields directed along the y axis.

MAGNETIC FIELD PROFILES

The magnetic field profiles for the first and second arms of the machine are shown in Figs. 1 and 2 respectively. The fields were measured using a sensitive 3-axis gauss meter (AlphaLab vector Gauss meter), scanned along all regions in the beam line where the wave-functions evolve coherently. This was done along the central molecular beam axis, as the variation of the magnetic field profiles are negligible within the lateral extent of the molecular beam (± 1 mm). The magnitude of the solenoid x fields changes depending on the value of the current that is passed through the solenoid, and is shown for one value of the current. For field values above several hundreds of gauss, such as those encountered at the end of the polariser (beginning of first dipole field), the nine m_I, m_J states are eigen-states of the hamiltonian to a good approximation, so it is not necessary to coherently propagate the quantum states through these high fields. For this reason, the exact position of the start of the first dipole and end of the second dipole fields do not need to be known exactly. This is in contrast to the region between these points, where knowing the exact 3d magnetic profile is essential for calculating the coherent propagation of the wave-functions correctly.

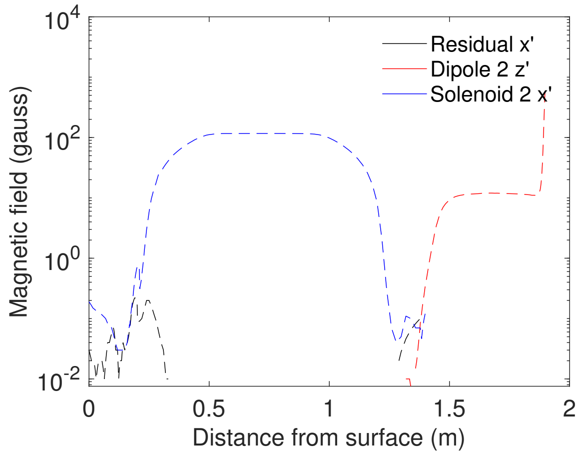

FIG. 2: The magnetic field profile for the second arm of the machine. Positive fields (with respect to the x' and z' axes) are shown as solid lines, and negative fields as dashed lines. There are no fields directed along the y' axis.

SCATTERING MATRICES

The general form of the scattering (S) matrices is

$$S = \begin{pmatrix} s_{11} & s_{10} & s_{1-1} \\ s_{01} & s_{00} & s_{0-1} \\ s_{-11} & s_{-10} & s_{-1-1} \end{pmatrix} \tag{1}$$

where each s_{fi} element corresponds to a transition between the initial m_J state i to the final m_J state f. The specific matrix values used for the figures in the manuscript are given below.

Identity matrix

Figures 3a and 4a

$$S = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{2}$$

Random unitary matrix

Figures 3b and 4b

$$S = \begin{pmatrix} -0.4798 - 0.3817i & 0.4020 - 0.2997i & 0.5930 - 0.1447i \\ -0.3886 - 0.2887i & -0.2958 + 0.7496i & -0.1320 - 0.2861i \\ 0.5930 - 0.1447i & -0.0042 - 0.3410i & -0.6079 + 0.3762i \end{pmatrix} \tag{3}$$

First random matrix

Figures 3c, 4c, 5a, 5b, 6, 7 and 8a

$$S = \begin{pmatrix} 0.0554 + 0.0637i & 0.2724 - 0.2927i & -0.2280 - 0.1248i \\ -0.7612 - 0.2466i & 0.2645 + 0.3408i & 0.5492 - 0.7263i \\ -0.1309 - 0.1262i & -0.1563 + 0.2125i & -0.1450 - 0.0121i \end{pmatrix} \tag{4}$$

Second random matrix

Figures 3d, 4d, 5c, 5d and 8b

$$S = \begin{pmatrix} -0.5024 - 0.6777i & 0.0142 - 0.0063i & 0.1684 + 0.1744i \\ -0.0498 + 0.1237i & 0.6978 + 0.3112i & 0.4476 + 0.5966i \\ -0.4435 - 0.2350i & 0.1866 - 0.4149i & -0.8452 - 0.1646i \end{pmatrix} \tag{5}$$