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Supplemental Information

Magnetic Susceptibility Difference-Induced Nucleus Positioning in Gradient Ultrahigh Magnetic Field

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Supplementary Material for

Magnetic susceptibility difference-induced nucleus positioning in gradient ultra-high magnetic field

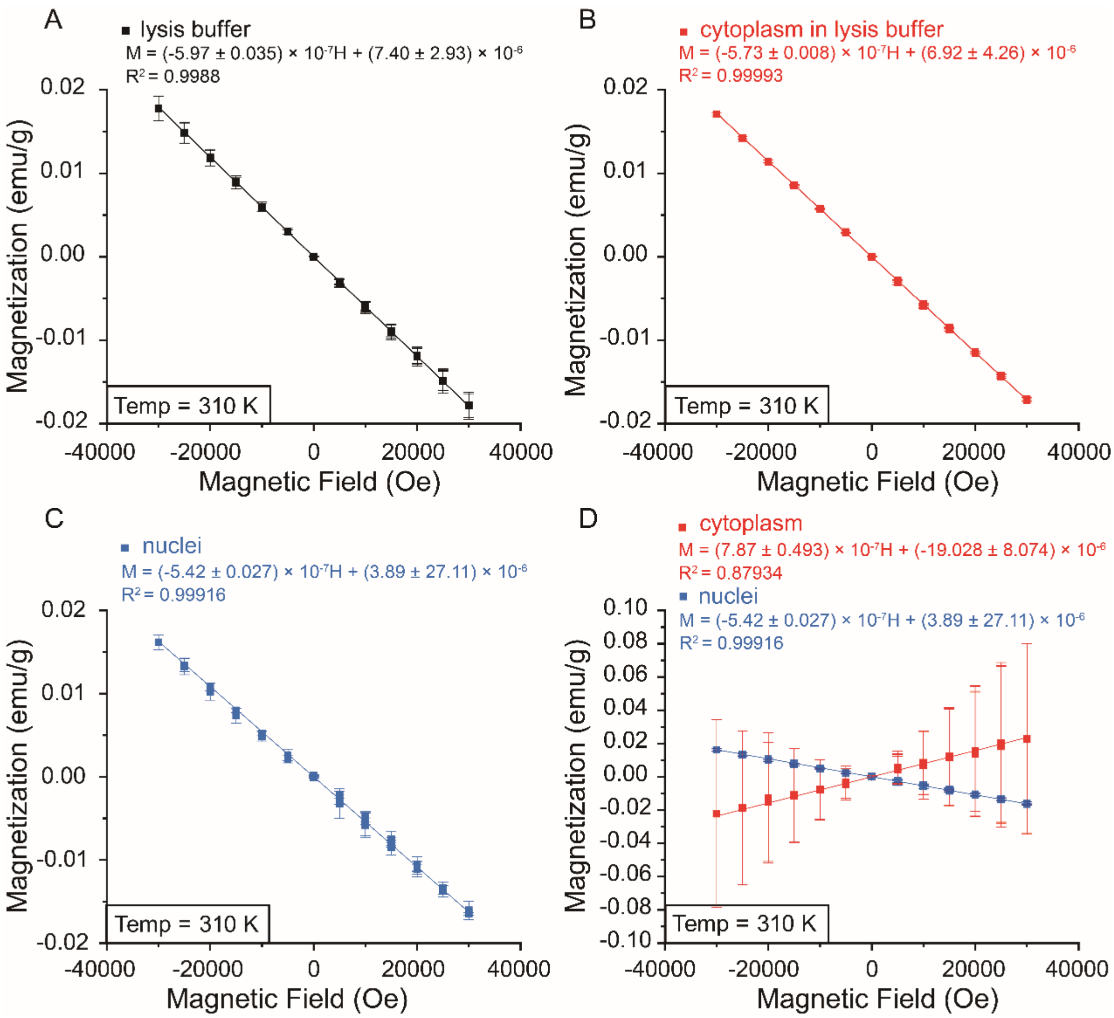

FIGURE S1 The measurement and linear fitting results of cell fractions. Magnetization versus magnetic field strength of (*A*) cell lysis buffer, (*B*) cell cytoplasm in lysis buffer, (*C*) nuclei and (*D*) calculated cytoplasm ruling out lysis buffer.

Force analysis of CNE-2Z cell nucleus

To simplify the model, we assumed that the cell nucleus is suspended in the cytoplasm, and both of the density of nuclei ρ_n and cytoplasm ρ_c are same with the density of water ρ_w as 1.0×10^3 kg/m³. And we got that the volume susceptibility, χ_v, through the product of the mass susceptibility χ_m and the density ρ of specific sample as

$$\chi_v = \chi_m \times \rho , \tag{S1}$$

Based on these assumptions, we got the volume susceptibility of nuclei $\chi_{v-n} = \chi_{m-n} \times \rho_n$ = -6.813×10^{-6} (SI), and the volume susceptibility of cytoplasm $\chi_{v-c} = \chi_{m-c} \times \rho_c$ = 9.888×10^{-6} (SI).

And the sizes of nuclei were assessed using Photoshop CS5 from fluorescent images of fixed CNE-2Z cell. Then the average radius of CNE-2Z cell nuclei R_n = 8.5 μm, the volume of cell nuclei $V_n = 4/3\pi R_n^3 = 2.571 \times 10^{-15}$ m³. Based on the formulas of gravity (Eq3), buoyance force (Eq4) and magnetic force with gradient of magnetic field (Eq5), the resultant force acted on cell nucleus can be calculated as Eq6.

At M0 position, B = 27 T, ∇B = 0 T/m, the magnetic force acted on cell nucleus $F_{mag} = \frac{V\Delta\chi}{\mu_0} B\nabla B = 0$ N, and the gravity $F_g = m_n g = \rho_n V_n g = 25$ pN, downwards. The buoyancy $F_b = \rho_c V_n g =$ 25 pN, upwards. So, at M0 position, the resultant force $F = F_g + F_b + F_{mag}$ = 0 N, we predict that the cell nucleus would not shift relative to the cytoplasm.

At M+1 position, B = 23.5 T, ∇B = -160 T/m, so the magnetic force acted on cell nucleus $F_{mag} = \frac{V\Delta\chi}{\mu_0} B\nabla B = +128.54$ pN, and plus is upwards. $F_g + F_b$ = 0 N, so the resultant force $F = F_g + F_b + F_{mag}$ = +128.54 pN. We predict that the nucleus would move up relative to the cytoplasm at M+1 position.

At M+2 position, B = 13.1 T, ∇B = -92 T/m, so the magnetic force acted on cell nucleus $F_{mag} = \frac{V\Delta\chi}{\mu_0} B\nabla B = +41.2$ pN, and plus is upwards. $F_g + F_b$ = 0 N, so the resultant force $F = F_g + F_b + F_{mag}$ = +41.2 pN. We predict that the nucleus would also move up relative to the cytoplasm at M+2 position.

At M-1 position, B = 23.5 T, ∇B = 160 T/m, so the magnetic force acted on cell nucleus $F_{mag} = \frac{V\Delta\chi}{\mu_0} B\nabla B = -128.54$ pN, and the minus sign represents downward direction. F_g+F_b = 0 N, so the resultant force F = F_g+F_b+F_{mag} = -128.54 pN, downwards. We predict that the nucleus would move down relative to the cytoplasm at M-1 position.

At M-2 position, B = 13.1 T, ∇B = 92 T/m, so the magnetic force acted on cell nucleus $F_{mag} = \frac{V\Delta\chi}{\mu_0} B\nabla B = -41.2\ \text{pN}$, and the minus sign represents downward direction. F_g+F_b = 0 N, so the resultant force F = F_g+F_b+F_{mag} = -41.2 pN. We predict that the nucleus would move down relative to the cytoplasm at M-2 position too.