Supporting information for the manuscript "Precise magnetic characterization of individual direct-write nanoelements"

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Note 1: Micromagnetic simulation results.

Figure S1 presents simulation results for the nanodisk with $R = 150\,\mathrm{nm}$. The resonance frequencies $f(H)$ increase almost linearly with increasing magnetic field, see Figure S1(a). The frequency separation between the neighboring resonances amounts to about 4.5 GHz, as is illustrated in Figure S1(b) for $H = 9\,\mathrm{kOe}$ which is very close to the resonance field for the third mode in the experiment. We have also checked that the micromagnetic simulations nicely reproduce the profiles of the spin-wave amplitude described by the zeroth-order Bessel functions in the analytical theory. For instance, if one takes a look at the fifth resonance mode, from the spatial profile of the spin-wave amplitude in Figure S1(c) follows that the involved spin wave length $\lambda \simeq 65\,\mathrm{nm}$ and such spin waves are in the dipole-exchange regime. At yet higher frequencies (and larger magnetic fields), higher excitation modes in the smallest nanodisks are represented by exchange-dominated spin waves.

Figure S1: Simulation results for the nanodisk with $R = 150\,\mathrm{nm}$.

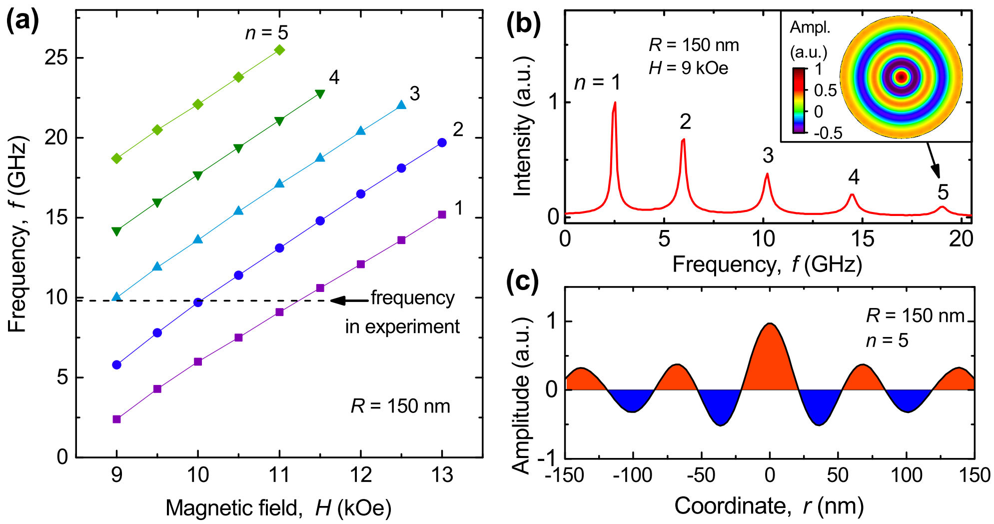

Figure S1. (a) Simulated dependences of the resonance frequencies on the magnetic field for the first five resonance modes for the disk with $R = 150\,\mathrm{nm}$. (b) Simulated spin-wave spectrum for the nanodisk with $R = 150\,\mathrm{nm}$ at $9\,\mathrm{kOe}$. Inset: Spatial dependence of the standing spin-wave amplitude for the fifth mode ($n = 5$) in the nanodisk. (c) Radial profile of the spin-wave amplitude for $n = 5$.

Animation 1: Simulation results for the nanodisk with $R = 300\,\mathrm{nm}$.

The animation illustrates the results of computer simulations using MuMax3 for the nanodisk with $R = 300\,\mathrm{nm}$. The upper (static) panel in the animation shows the simulated spin-wave resonance spectrum at an applied magnetic field of $15\,\mathrm{kOe}$. The lower (animated) panel depicts the coordinate dependence of the spin-wave amplitude for the forth mode ($n = 4$) at $11.13\,\mathrm{GHz}$.