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ABSTRACT

Two-dimensional arrays of bi-component. An abstract section is required for all CHI 2019 extended abstract submissions and should be about 150 words. To continue with your abstract text, authors will need to manually include the balance of text into column 2 on the next page. Use a good breaking point (like an end of a sentence).

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Figure 1: MOKE hysteresis loop for the bi-component Py/Co dots array measured along the dots long axis.

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Ø3		

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Sample Text & Equations are here. For each micromagnetic cell the reduced magnetization takes the form where the magnetization (saturation magnetization) in the k-th cell; note that the saturation magnetization now depends on the ferromagnetic material through the index k. Hence, in a polar reference frame

$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k} \quad (1)$$

where K is the azimuthal (polar) angle of the magnetization (the time dependence is omitted). The second derivatives of the energy density depend on the micromagnetic cell indexes, and through them on the material index corresponding either to Py or Co.
Note that, exchange contribution is set equal to zero, because in each unit cell the two elliptical dots are separated. Moreover, the uniaxial anisotropy energy density of Co is neglected Table 1.

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} \quad (2)$$

Therefore one can observe either an in-phase (acoustic) or an out-of-phase (optical) character of the modes, with respect to the precession of the in-plane magnetization components in adjacent Py and Co dots.

We would like to mention that the DMM presents several advantages with respect to OOMMF for calculating the spectrum of magnetic eigenmodes for the following reasons: *a*) There is no need to excite the system by any magnetic field pulse, *b)* A single calculation llows to determine the frequencies and eigenvectors of all spin-wave modes of any symmetry, *c*) The spectrum is computed directly in the frequency domain, *d*) The mode degeneracy is successfully solved, *e*) The spatial profiles of the spin-wave modes are directly determined as eigenvectors and, finally, *f*) The differential scattering cross-section can be calculated accurately from the eigenvectors associated to each spin-wave mode. This is a clear indication that both the Py and Co sub-elements are in a single domain state where Py and Co magnetizations are all oriented with their magnetic moment along the chain and field direction. At point β ($H = -372$ Oe) of the hysteresis loop, where the plateau is observed in the *M-H* loop, the dark and bright spots of the Py dots are reversed with respect to those of Co, accounting for an antiparallel relative alignment of magnetization.

Figure 2: MFM images of the bi-component Py/Co dots for different values of the applied magnetic field which are indicated by greek letters along both the major and minor hysteresis loop.

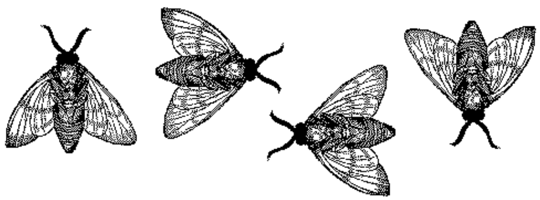

Figure 3: Dependence of the magnetic eigeinmode wave frequency on the applied field strength.

Figure 4: Calculated spatial distribution of the in-plane dynamic magnetization.

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RESULTS AND DISCUSSION

Magnetization Curves and MFM Characterization

The major hysteresis loop measured by MOKE, plotted in Fig. 1, displays a two-step switching process due to the distinct magnetization reversal of the Py and Co sub-elements, characterized by a different coercivity. We performed a field-dependent MFM analysis whose main results are reported in Fig. 2. At large positive field ($H = +800$ Oe, not shown here) and at remanence (α point of the hysteresis loop of Fig. 1), the structures are characterized by a strong dipolar contrast due to the stray fields emanated from both the Py and Co dots.

We have also used MFM to measure the magnetic configurations along the minor hysteresis loop, described above. Once the AP ground state has been generated at $H = -500$ Oe, the applied field is increased in the positive direction. The MFM image taken at point of Fig. 2, remanent state of the minor loop ($H = 0$), shows that the AP state is stable and remains unchanged until the magnetic field is increased up to +300 Oe where the Py magnetization reverses its orientation and returns to be aligned with that of Co dots. On the basis of the above MFM investigation, one can say that the structures are always in a single domain state, while the relative magnetization orientation between the adjacent Py and Co elements depends on both the field value and the sample history.

Field Dependent BLS Measurements and DMM Calculations

Fig. 3 displays the frequencies of BLS peaks plotted as a function of the applied field magnitude starting from positive values. The field is then decreased and reversed following the upper branch of the hysteresis loop, shown in the same figure. Up to five peaks are measured in the spectra, as shown in spectrum measured at H = 0 Oe in the Fig. 3 inset, and their field evolution analyzed over the whole field range investigated. The detected modes are identified and labeled on the basis of their calculated spatial profiles, shown in Fig. 4 for $H = 500$ and -500 Oe. They exhibit marked localization into either the Co or the Py dots, as stated at the end of the previous Section, were it was introduced the labelling notation containing the dominant localization region (either Py or Co) and the spatial symmetry (EM, F, DE, etc).

When the dots are in the P state, up to five modes were detected in BLS spectra. On the basis of the calculated profiles (right panel of Fig. 4), we identified in the P state the two modes at lowest frequencies as the EM(Py) and the F(Py), with a very small spin precession amplitude into the Co dot. This is because for this material we are below the frequency threshold for the existence of spin waves. A similar effect has been observed in periodic array of alternating Permalloy and Co nanostripes

The reason of this complex behavior will be addressed in the following, analyzing the interplay of both static and dynamic dipolar coupling between the adjacent Py and Co dots Table 2.

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Table 2: Comparison of Coefficients from Atomistic

Atm	*MS-CG*	*MS-CG/DPD*
1.78	14.32	1.74 (–2%)
0.43	31.00	0.40 (–7%)
0.062	15.61	0.048 (–23%)
0.032	9.76	0.024 (–24%)
0.020	4.66	0.015 (–25%)
0.012	2.32	-”-
0.0076	0.016	-”-

ACKNOWLEDGMENTS

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CONCLUSIONS

In summary, we have performed both an experimental and theoretical study of the spin eigenmodes in dipolarly coupled bi-component cobalt and permalloy elliptical nanodots. Several eigenmodes have been identified and their frequency evolution as a function of the intensity of the applied magnetic field has been measured by Brillouin light scattering technique, encompassing the ground states where the cobalt and permalloy dots magnetizations are parallel or anti-parallel, respectively.

REFERENCES

[1] All references should be in the alphabetical order by last name of the first author. See how the reference list is numbered with square brackets using the WORD settings, 8 pt. Linux Biolinum and justified text (flush left and right), text indent hang off the numbering. **It is mandatory to use the square brackets for the references numbered list.**

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