Institute of Magnetism of the NAS of Ukraine and MES of Ukraine

THE DEVELOPMENT OF PHYSICAL PRINCIPLES OF MAGNETIC NANOELECTRONICS

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NATIONAL RESEARCH
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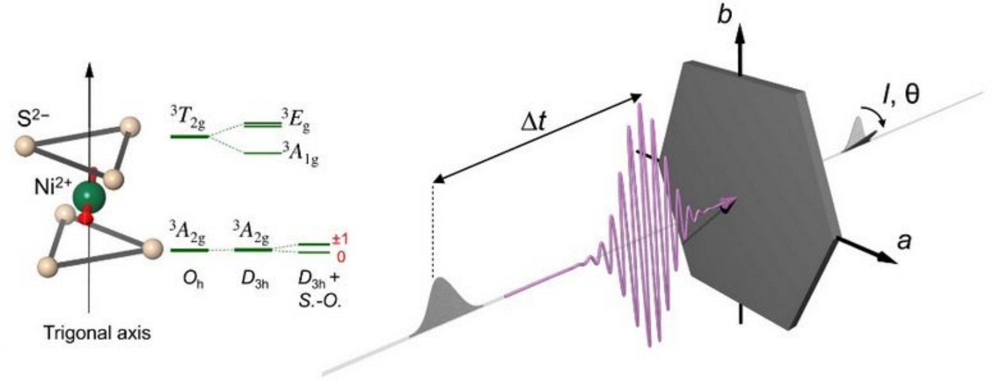
NRFU call “Support for research of leading and young scientists”

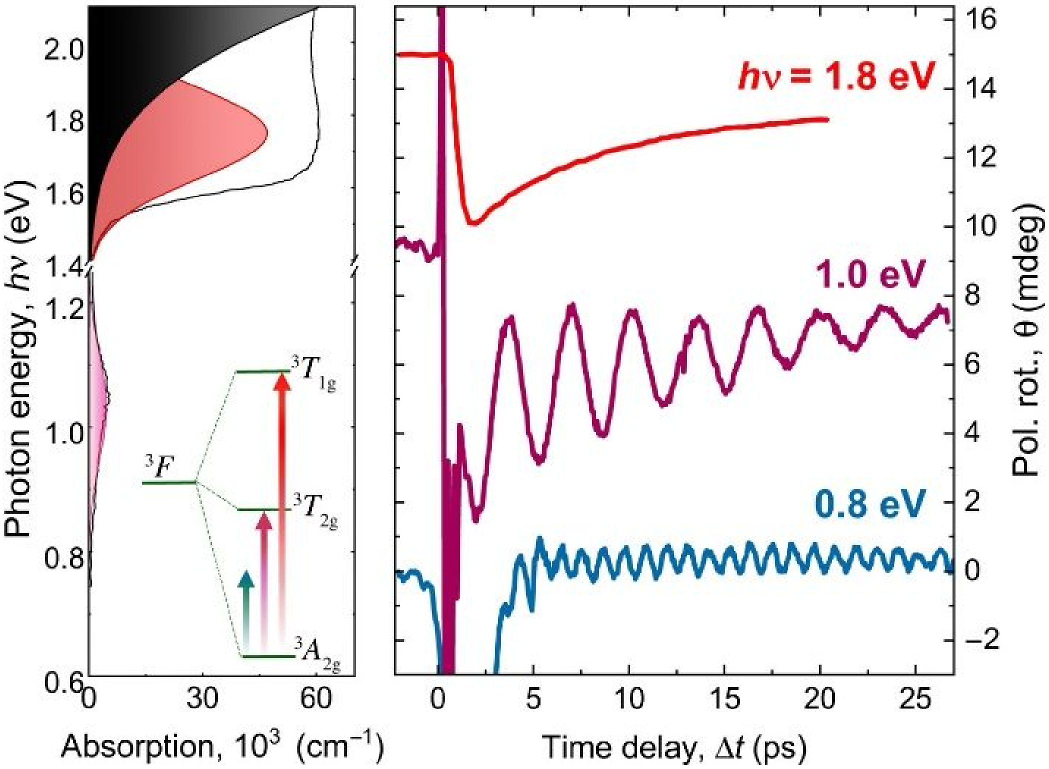
OBJECTIVES

The goal of the project is to develop physical principles for the construction of telecommunication systems and microwave and information processing systems based on magnetically ordered materials, which would overcome the limitations on speed and energy efficiency of modern semiconductor systems.

It is planned to study physical processes in nanostructured magnetically ordered materials: pico- and nanosecond dynamics, peculiarities of formation and growth of functional nanostructures, etc., and, using the studied effects, to formulate principles of creation of individual elements and integrated systems of high-speed magnetic nanoelectronics.

MAIN RESULTS

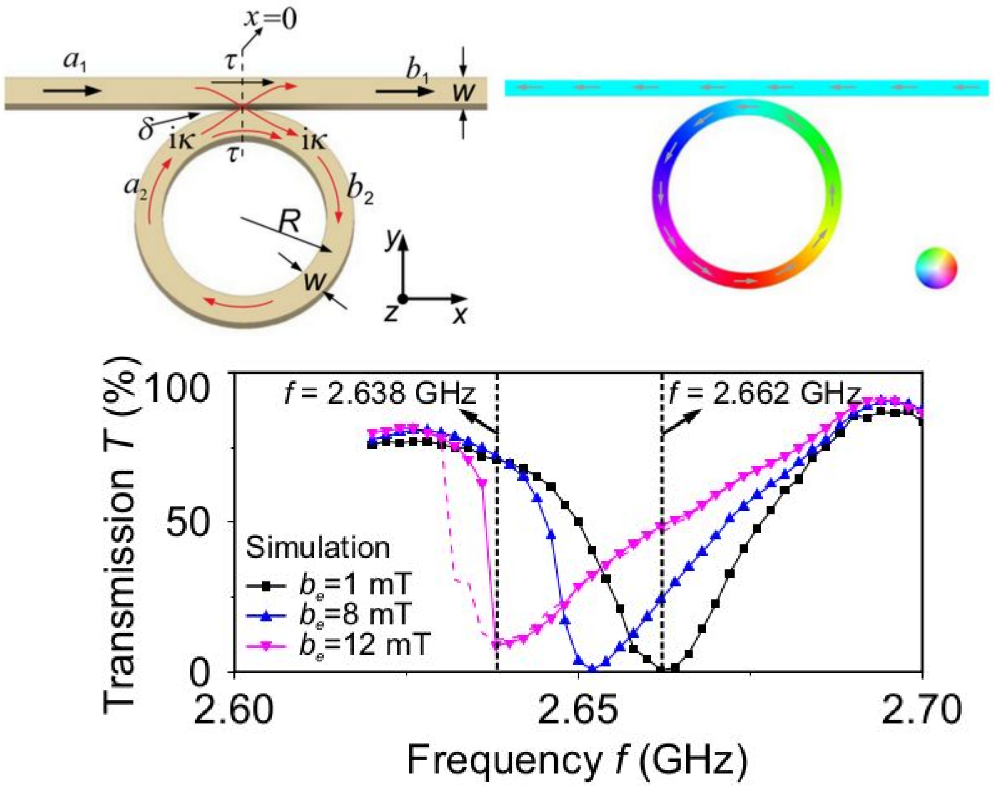




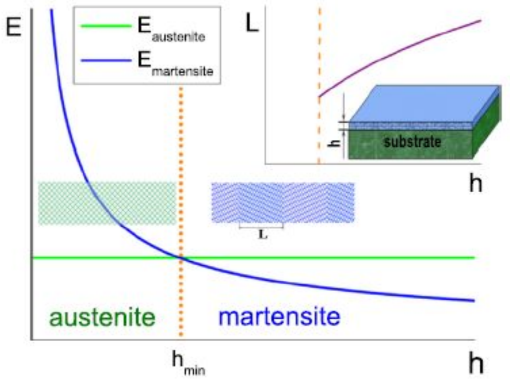
It was established, that ***selective pumping of orbital resonances*** is an effective method for control of magnetic anisotropy and ***excitation of high-frequency coherent spin dynamics in a Van-der-Waals antiferromagnets***, which opens new possibilities for the creation of spin information processing devices operating in the subterahertz frequency range.

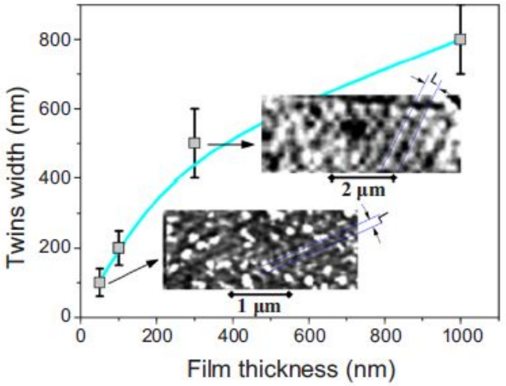
MAIN RESULTS

A ***nanoscale nonlinear magnon ring resonator*** is proposed and theoretically investigated. It has been shown that in the nonlinear regime, the resonant frequencies shift takes place and the transfer curves become asymmetric. At a sufficiently large input power, these curves demonstrate bistability, i.e. the transmission at the frequency of linear resonance exhibits threshold behavior: spin waves of low input power are stored in the ring structure, and the system generates output only if the input power exceeds a threshold. This can be useful for different applications, for example, in magnonic neural networks or to provide power limiter-type transfer.



MAIN RESULTS

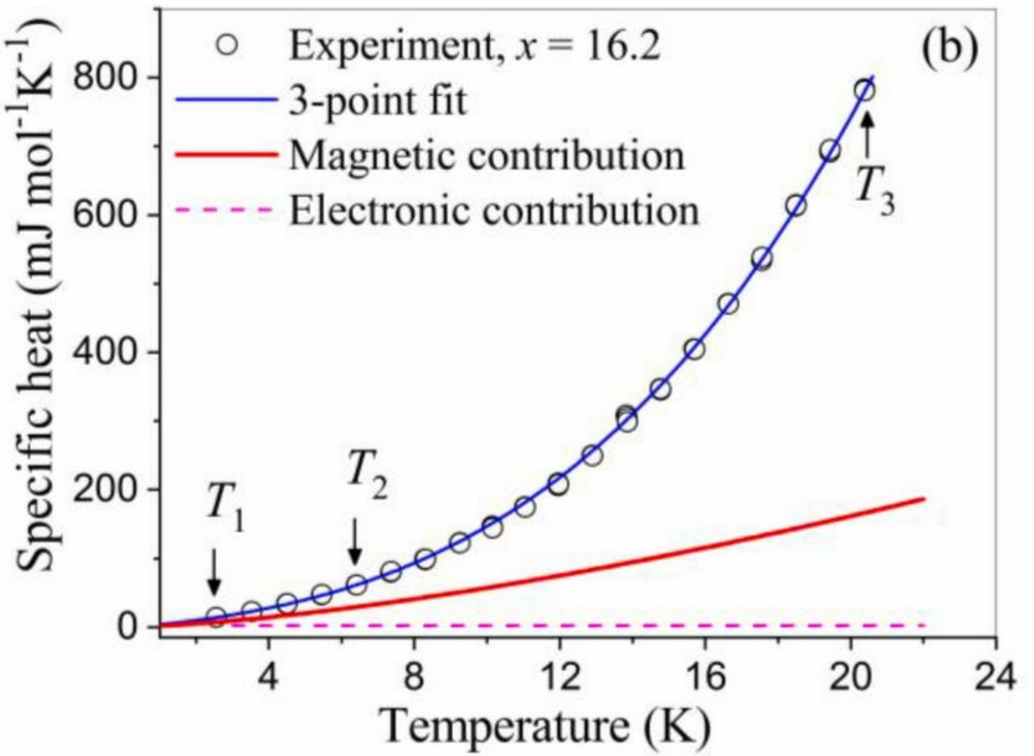




The influence of film thickness on the formation of the twin structure and its transformation, as well as on the magnetic properties of epitaxial films of magnetic shape memory alloys, has been studied. It has been shown that the interplay between the elastic energy on the film-substrate interface and the energy of the twin boundaries leads to the ***formation of a submicron periodic stripe-like twin structure***. It has been established that the stresses near the film-substrate boundary block the martensitic transformation in thin films. An increase in the film thickness leads to a decrease in these stresses, and the martensitic transformation becomes possible. The width of the twin variants increases with films thickness increasing, which leads to a dramatic modification of their magnetic properties. Our results show a fairly ***simple way to obtain nanoscale spatially periodic structures with sharp twin boundaries*** in epitaxial films of magnetic shape memory alloys. The magnetic properties of such films can be modified in a wide range by choosing the required film thickness. Such structures are promising for application in spintronics and magnonics devices.

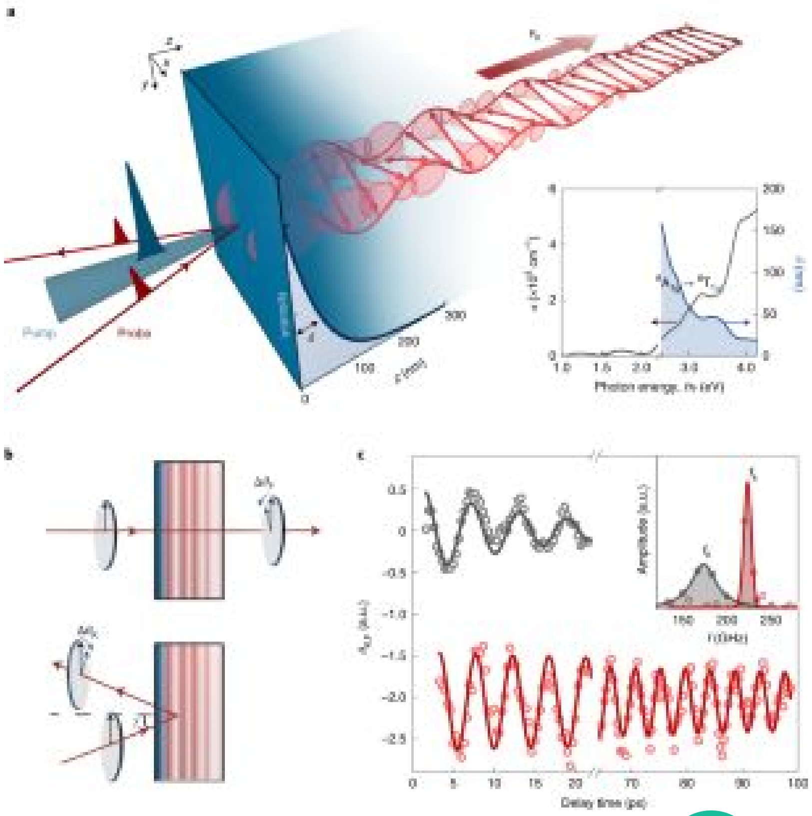
MAIN RESULTS

A theoretical analysis of the normal and inverse ***magnetocaloric effects in antiferromagnetic shape memory alloys*** with two magnetic sublattices was carried out. It was shown that the adiabatic temperature change depends on the change in entropy caused by the magnetic field and the heat capacity of the alloy. Magnetic and non-magnetic contributions to the heat capacity were taken into account and estimated. The contribution of spontaneous deformation accompanying the magnetostructural phase transition to the total value of the magnetocaloric effect was clarified. The change in heat capacity due to the change in the magnetic state of the alloy during the phase transition was calculated. The results are important for the creation of ***solid-state cooling systems***.



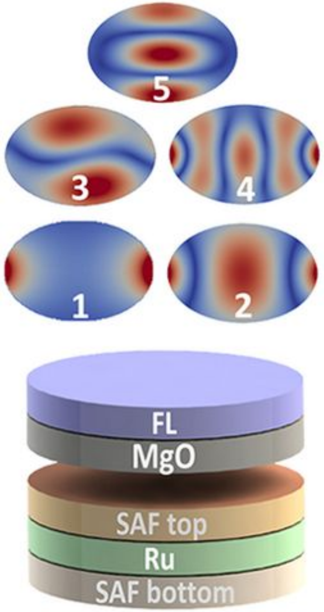
MAIN RESULTS

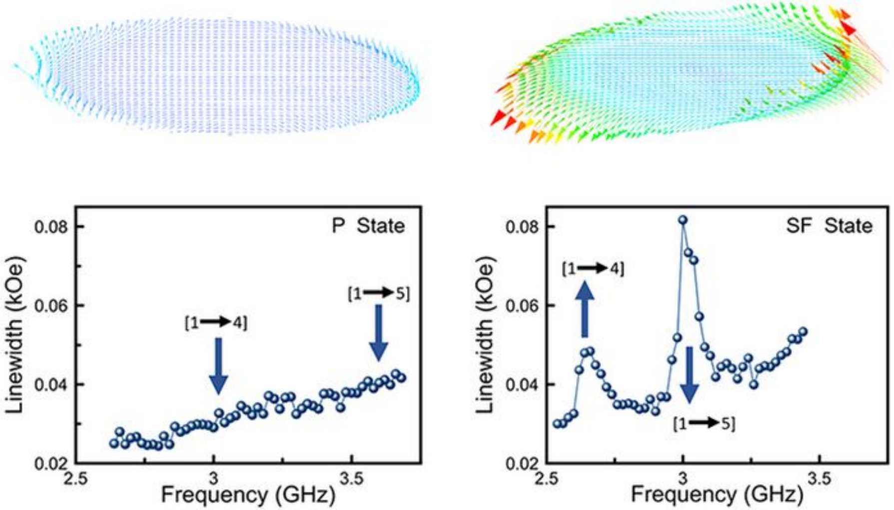
A practically universal method of ***exciting coherent propagating spin waves in antiferromagnetic insulators*** by optical pumping of electronic transitions above the band gap is proposed. Powerful optical absorption makes it possible to spatially confine light in the subwavelength range, which is inaccessible to any other methods, and allows obtaining a ***broadband continuum of short-wave AFM magnons***. This mechanism opens up prospects for THz coherent AFM magnonics and opto-spintronics, providing a source of coherent high-speed spin waves.



MAIN RESULTS

The possibility of a ***controlled increase in the efficiency of the three-magnon interaction*** by at least an order of magnitude has been demonstrated. The application of an inhomogeneous magnetic field removes the symmetry restriction for magnon-magnon scattering processes, which affects the scattering rate. The possibility to manipulate the interaction of magnon modes in a magnetic nanoelement has been demonstrated.





Various dissipative states that arise as a result of modified three-magnon interaction expand the range of applications of magnetic nanostructures in spin-torque magnetic memory, spin-transfer oscillators, microwave detectors, and spin-wave logic elements.

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