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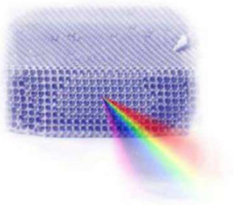
Kopaonik, March 13-16, 2022



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15th Photonics Workshop

(Conference)

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Book of abstracts

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Valence Band Electronic Structure of Hybrid Nanoparticles Studied by Synchrotron Radiation Aerosol Photoemission Spectroscopy

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Abstract. Aerosol photoemission spectroscopy is an important method for studying the electronic structure of submicrometer particles, free from the influence of substrate or solvent [1-4]. This technique relies on the interaction of focused beam of particles (typically ~100 nm in size) with ionizing radiation under high vacuum conditions. In this approach the aerosol particles can be directly produced from a solution or a colloidal dispersion, which opens a possibility for investigations of a variety of hybrid nanosystems that can be produced by conventional wet chemistry methods. In addition, by using tunable synchrotron radiation as an excitation source one can obtain high-resolution photoelectron spectra in the investigated kinetic energy range. In this report, we describe the methodology and present the results of the aerosol photoemission spectroscopy studies of different hybrid nanostructures, including hybrid perovskites and biomolecule-functionalized nanoparticles.

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Using artificial neural networks to make temperature sensing calibration curve

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Abstract. In this study we analyze possibilities of determining the temperature sensing calibration curve of thermophosphors using artificial neural networks (ANN). For machine learning analysis of data we have used Solo+Mia software package (Version 9.0, Eigenvector Research Inc, USA). Experimental results were obtained using experimental setup presented in detail in [1,2]. Upconverting material was excited at 980 nm by using pulsed laser diode. Usual, conventional way is to use intensity ratios of spectral lines for determining the calibration curves for remote temperature sensing [3-5]. Based on thus obtained data we have trained the neural network to recognize temperature of sample based on its luminescence spectrum. For training we have used 69 measured spectral points between 525 nm and 560 nm, so the neural network has 69 input nodes. Although training of neural network took some time (in minutes, on i7 processor based laptop), the neural network provides quick and strait answer when questioned with data of samples heated to unknown temperatures. Predicted values of two unknown temperatures provided by the neural network in Fig. 1. are about 401 K and 572 K. This kind of approach is very versatile, and, if needed, improved by deep learning.

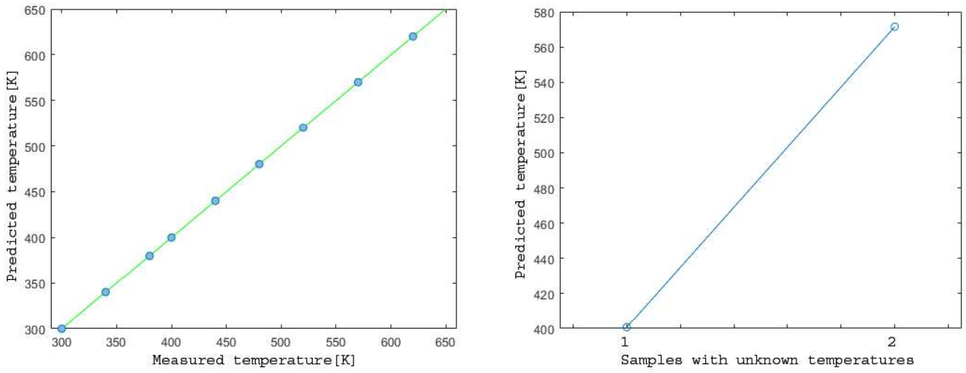

Figure 1. Temperature sensing calibration curve obtained by ANN, simulated by SOLO software (left), predicted temperatures of samples heated to unknown temperatures (right).

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Photonic, electronic and ionic collisional data represented in Belgrade database for inner-shell excitation and ionization of atoms

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Abstract. The inner-shell excitation and ionization of atoms have been extensively studied during past 60 years, primaraly owing to the development of spectroscopic methods used by synchrotron radiation and in less extent by electron impact. Different kind of photonic, electronic and ionic data have been covered by VAMDC and RADAM [1] consortia. Our aim is to develop a possibility of storing ejected electron spectra obtained either by photoelectron or electron spectroscopy methods in which recorded electron intensities are shown versus incident photon/electron energy or kinetic energy of ejected/scattered electrons. A specific database designed for the curation of such spectra is BeamDB – Belgrade Electron Atom/Molecule DataBase [2] with the example of the spectrum given in Fig.1.

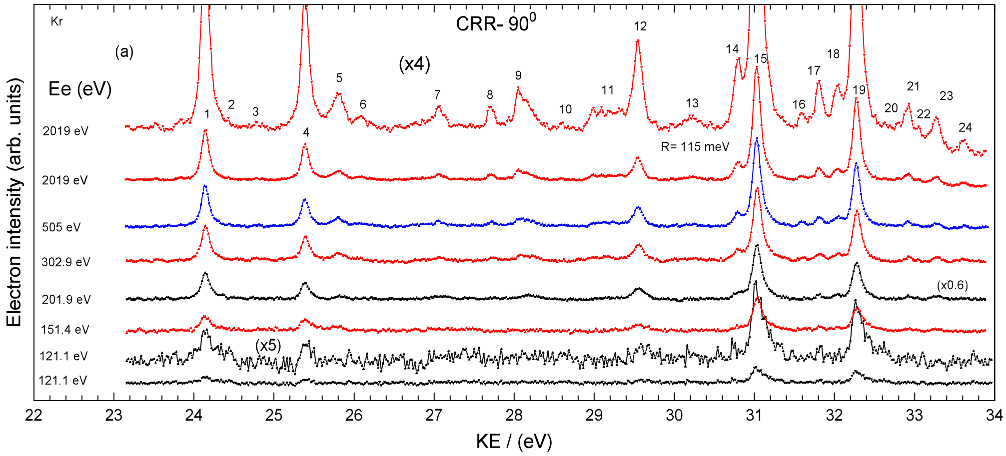

Figure 1. An example of the ejected-electron spectrum of Kr in the 22-34 eV range obtained at electron impact energies from 121.1 to 2019 eV [3].

The interpretation of spectra is complicated not only by configuration interaction in the initial states but also by the fact that often the binding energies of neither the initial nor final states are known accurately. De-excitation pathways due to Auger transitions may lead to multiple ionized atomic species (for Xe atom they have been investigated up to Xe^{6+}) [4].

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Dynamic interference of photoelectrons in two-photon ionization of hydrogen by intense short laser pulses

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Abstract. We studied sequential two-photon ionization of hydrogen atom whose ground (1s) and excited 2p states are coupled resonantly by an intense short laser pulse. The populations of states, as well as the photoelectron energy spectrum (PES), are calculated numerically using the wave-packet propagation method. The obtained PES shows an intensity dependent splitting of the resonant peak and associated modulations. The numerical results are analyzed using a three-level model (1s, 2p, continuum) [1]. It is shown that the splitting can be attributed to the existence of two dressed states whose quasi-energies repel each other by the field-induced coupling. On the other hand the modulations can be explained by the dynamic interference of the electron wave packets emitted with the same energy, but with a time delay at the rising and falling sides of the pulse.

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DC Transverse Magnetic Field Scan in True Scalar Cs Magnetometers

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Abstract. We present a true scalar magnetometer (TSM) consisting of a paraffin-coated glass cell filled with Cs vapor with the $\overrightarrow{B_{rf}} \parallel \vec{k}$ geometry where $\vec{k}$ is the light propagation direction for the optical pumping and $\overrightarrow{B_{rf}}$ is a magnetic field oscillating at Larmor frequency [1]. Spin dynamics of this system are described by the Bloch equations in Cartesian spin components:

$$\frac{d\vec{S}}{dt} = \vec{S} \times \vec{\omega} - \gamma\vec{S} + \gamma_p\vec{k}.$$

The measurement of a DC magnetic field transverse to the main magnetic field in the system produced unexpected signal shapes in different transverse directions. Specifically, with the RF field in the YZ plane, the DC field in the x-direction produces unfavorable signal when modulated at sufficiently high frequencies. This difference in the dynamic RF projection phase is investigated by solving the above equation both analytically and numerically with different transverse field geometries. The theoretical calculations produce results that are in good agreement with the observed systematic effects during measurement.

We will present the measurements in both described geometries and discuss the differences between the obtained signals. We will also present the details of both calculation processes and discuss how the results compare to the measurements.

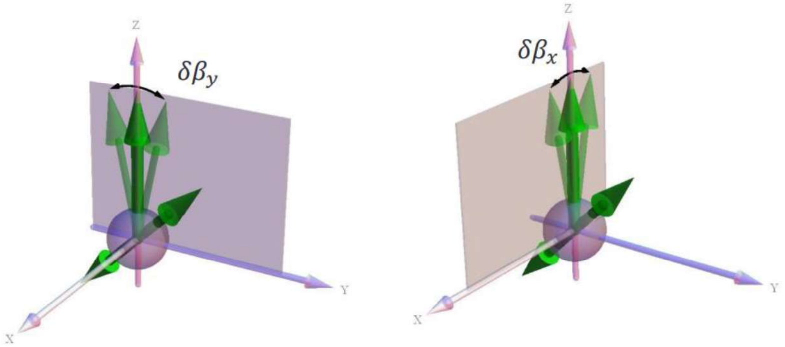

Figure 1. Two different field geometries considered for the DC transverse magnetic field scans. The additional magnetic DC field manifests as a small “rotation” of the main field in the appropriate direction.

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Why do we need accurate magnetometers and how to realize them

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Abstract. In most cases magnetometers have been developed with accent on sensitivity in order to detect very small changes of magnetic fields like brain waves, magnetic field of beating hart or variations of geomagnetic field. For such applications exist wide range of devices like fluxgates, GMR, SQUID, OPM (Optically Pumped Magnetometer), etc. [1]. Our goal is to improve accuracy or precision of OPMs based on vapors of alkali metals while retaining most of their sensitivity. Alkali metals are very well studied, their properties are measured and theoretically calculated to high precision. It is to expect that a sensor, based on, for example cesium, should be easy to deploy and understand in various schemes. It turned out this is not the case and future research is required in order to overcome heading errors of cesium based OPMs.

Accurate OPMs would have broad range of applications like precision experiments in fundamental research (like measurement of nEDM – neutron Electrical Dipole Moment), metrology, space explorations and for mapping of geomagnetic fields. The latter would benefit in archaeology, mining operations and from improved quality in tracking changes in global distribution and intensity of the Earth's magnetic field.

In my talk I will present the old nEDM experiment at PSI [2] and its improvements towards its next generation – n2EDM [3]. The last part of the talk will be dedicated to accurate magnetometry with Free Spin Precession (FSP) [4] and Free Alignment Precession (FAP) magnetometers. If time permits, prospects of a ^{4}He magnetometer will be discussed.

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All-optical Cs magnetometer based on free alignment precession

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Abstract. Since their first demonstration, in 1960s [1], optically pumped atomic-based magnetometers (OPM) [2] have been in the focus of many scientific studies. Recently, they have been of special interest due to their wide range of application, including measurements of magnetic fields in bio-medical science, environmental and geo-science.

Our focus is on the development of a compact, portable magnetometer for geophysical field measurements. We present the design and operating principle of a novel kind of OPMs, optically-pumped Cs magnetometer based on a free alignment precession (FAP). This type of magnetometer is free of some limitations of conventional OPMs, such as frequency shifts and systematic displacements. We use a paraffin-coated Cs vapor cell. Magnetometer operates at room temperature. The atomic medium is pumped with linearly polarized amplitude-modulated light at a double Larmor frequency, $2\omega_L$. This process generates spin alignment. After the optical pumping, the decay of the spin polarization can be detected in the weaker probe beam passing through the cell. The information on the magnetic field and Larmor frequency can be gathered via further signal processing.

We will discuss the influence of various parameters on the performance of our magnetometer – state of polarization of the probe and pump beam, angle between the probe and the external magnetic field, probe and pump powers and lengths. We will present our set-up and first test measurements. Finally, we will give an outlook for the further work.

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