Phisycs faculty seminar

The purpose of the seminar is to inform colleagues about the research results, current scientific publications, recent achievements in physics; discussing the prospects for joint research, strengthening the interaction between the theoretical and experimental links of the faculty, and the possibilities of more efficient use of experimental equipment.

Colleagues from other universities and research institutes are invited to report.

Please send applications to the report at olena.m.savchenko@gmail.com. In the application it is necessary to specify the regalia of the speaker, the place of work, the contact phone number, the title of the report, the desired date. Reports are accompanied by a computer presentation. Simultaneously with the application, the speaker must submit abstracts (abstract) in English for publication in The Journal of V.N. Karazin Kharkiv National University "Physics series".

Below are abstracts of reports of 2019 year.

January 23

Традиційні і нетрадиційні магнетооптичні ефекти в фізичних експериментах

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February 27

Photometry of asteroids

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Photometry is one of the most productive techniques of investigations of physical properties of small Solar system bodies. This technique is successfully used for asteroids for a long time. A big massive of various data for many thousand asteroids is obtained with this method and a correctness of these data is confirmed by space missions for some of asteroids. The primary information obtained from single photometric observations of an asteroid is the absolute magnitude that allows to make an estimation of the object size. This is widely applied first of all to the newly discovered

asteroids, particularly for potentially hazardous ones that may come into collision with the Earth. Long-term photometric observations allow obtaining a lightcurve of an asteroid to determine its rotational period, direction of rotational axis in the space, shape of the body, and optical properties of surface. At present the rotational periods for about seventeen thousand asteroids were determined and about three hundred of binary asteroid systems were found for last ten years. More than one thousand positions of rotational axes and reconstruction shapes of asteroids were obtained from an analysis of the lightcurves, occultation silhouettes and direct images. Also new effects in the light scattering by asteroid surfaces were discovered, and it was proposed some new functions for determination of an asteroid absolute magnitude and for the ephemerid computation of the apparent magnitude. The main directions of asteroid photometry for the nearest years can be summarized as following: study of the rotational characteristics of the asteroid groups and families (rotation periods, coordinates of poles, YORP-effect, etc.); observations of the lightcurves for the selected asteroids for modeling their shape; ground-base photometric observations in support of radar research and space missions; search for binary and multiple systems, especially in the outer part of the main-belt; obtaining high-precision magnitude-phase dependencies of main-belt asteroids and NEAs to study the optical properties of their surfaces and to verify approximation functions used for determination of absolute magnitude.

March 27

Vibration Effects in Electron Transport in Single Molecule Transistors

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Single molecule transistors (SMT) are promising candidates for basic elements in nanoelectronics. Current-voltage (I-V) characteristics of SMT demonstrate all main effects known for single electron transistors – Coulomb blockade and Coulomb blockade oscillations on gate voltage. Besides I-V curves of SMT show specific low energy features (steps) attributed to vibration degrees of freedom. A theory of vibration effects in molecular transistors predicts steps caused by inelastic channels of electron tunneling in I-V characteristics and Franck—Condon (polaronic) blockade of conductance at low temperatures. With the increase of temperature polaronic blockade is lifted and this behavior in the case of strong electron-vibron interaction results in anomalous (non-monotonic) dependence of conductance on temperature. Franck—Condon steps, Franck—Condon blockade and anomalous temperature dependence of conductance were observed in experiments with suspended single-wall nanotubes and carbon nano-peapods.

One more novel effect in electron transport in SMT is single electron shuttling. We consider shuttling of spin-polarized electrons in a spintronic molecular transistor with magnetic leads. In particular, the properties of thermally driven magnetic shuttle are discussed.

April 24

Determination of Characteristics of Substructure and Orientation Inhomogeneity in Polycrystalline Specimens

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It is well known that the structure, substructure and orientation inhomogeneity affects the physical and more mechanical properties of a crystalline materials. Therefore, the problem of determining the orientation and structure inhomogeneity of crystalline specimens seems quite important and actual. As a rule, the inhomogeneity is determined by diffraction methods from a small area of the specimen as compared to its size. These methods do not allowed in situ study of structural and orientational changes in specimens during external action. The suggested opto-electronic technique for the study of orientation and structure inhomogeneity of the surface of a crystalline specimens allows to solve this problem.

The technique is based on the observed effect of diffraction of white light by quasiperiodic etching relief of the surface of a crystalline materials. The recording scheme includes a special lighting system and a digital photosensitive device connected to a computer. It allows to obtain the color orientation maps of the whole surface of a specimen in the RGB space, where the crystallographic orientation of individual segment of the specimen's surface and the color of her image is in one correspondence.

It should be noted that the RGB color space, where there is the ability to differentiate 16,7 million hues, was used for color orientation mapping of the surface of a Al polycrystal. The number of hues of each of the three primary colors is 256. Such a large number of hues of color in the RGB color space does not allow to visualize the area of the specimen's surface with a specific crystallographic orientation and clearly establish the connection between the color hue of the specific area of the specimen's surface and its crystallographic orientation.

May 22

Туннельно - термоактивационный механизм диффузии вакансий и примесных атомов в квантовых кристаллах

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Рассматривается новый механизм транспорта вещества в квантовых кристаллах - диффузию точечных дефектов как псевдочастиц с метастабильными квантовыми состояниями, способных к туннельному и термически активированному перемещению между узлами кристаллической решетки.

Данная работа существенно дополняет разработанную ранее теорию квантовой диффузии делокализованных квазичастиц (И. М. Лифшиц и др., УФН, т. 118, с. 251, 1976; УФН, т. 147, с. 541, 1983).

Выводы проведенного теоретического анализа сравниваются с результатами экспериментального исследования процесса ползучести кристаллов Не в области температур: $0{,}1^{\circ}\mathrm{K} \leq T \leq 2^{\circ}\mathrm{K}$.

June 26

Lower hybrid cavities in the Earth ionosphere

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In plasma of the Earth ionosphere the axially symmetric regions elongated along the geomagnetic field are observed, which are characterized by a depleted density of plasma in comparison with the environment as well as an increased level of oscillations in the range of the lower hybrid frequency. Such regions called the lower hybrid cavities (LHC) have transverse dimensions of several thermal ion gyroradii usually several tens of meters. The registration and measurements of the LHC are carried out by satellites as well as sounding rockets, and it occurs only when they pass through these structures. Although there are a number of works on the explanation of this phenomenon, the mechanisms for occurrence of LHC, as well as their stability, are not completely clear. There are also no estimates of the time of their existence and the explanations of their disappearance. In this report, we discussed the problems of the formation of cavities in ionosphere plasma as well as their disappearance.

As a possible mechanism for the formation of cavities in plasma, we consider the effect of the interaction of charged particles with the electrostatic turbulence of plasma. In the Earth's ionosphere upflowing and downflowing beams of charged particles are observed. It is known that the passage of charged particle beams through plasma leads to various instabilities and to the turbulent state of plasma. In turn, the turbulence of uniform plasma is the cause of the change in its distribution function, that is, the heating of plasma. However, in addition to heating, electrostatic turbulence can also lead to the diffusion of plasma particles. Such motion of charged particles is similar to the motion of Brownian particles, which is caused by collisions with molecules of a liquid. Charged plasma particles (ions or electrons) "collide" with chaotic pulsations of the electric field, which leads to diffusion motion. If the electrostatic turbulence is spatially nonuniform, then in addition to the diffusion process, the drift motion of the plasma particles induced by the ponderomotive force also occurs, which leads to transport of particles from region with an increased level of turbulence. As a result, a region with a depleted density of plasma is formed.

As a possible mechanism for the disappearance of LHC we consider the anomalous diffusion of inhomogeneous plasma across the geomagnetic field. It is known that in magnetized plasma the excitation of various instabilities due to the radial inhomogeneity of the plasma density is possible. One of them is the drift lower hybrid instability due to which an increased level of low hybrid oscillations in the LHC is believed to occur. In addition, it is possible the excitation of a drift instability with a frequency much less than the ion cyclotron frequency, which can lead to the lower frequency drift turbulence of plasma. In turn, due to the drift turbulence, an anomalous diffusion of plasma across the magnetic field occurs, which should lead to the filling of the LHC with plasma and its disappearance.

September 25

Гальванічні досліди в Імператорському Харківському університеті. До 160 річниці з дня проведення та 210 річниці з дня народження професора Лапшина В.І.

В.П. Пойда

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Відбулося засідання наукового семінару фізичного факультету на якому професор Пойда В.П. зробив доповідь на тему «Гальванічні досліди в Імператорському Харківському університеті», в якій розповів про

особливості проведення гальванічних дослідів у Імператорському Харківському університеті. Ці досліди, які були першими комплексним дослідженнями, проведеними у галузі експериментальної фізики у Російській Імперії. Вони здійснені в Імператорському Харківському університеті у серпні-вересні 1859 року з використанням потужного джерела електричного струму, яке складалося із 1000 гальванічних елементів Бунзена.

У ході гальванічних дослідів, які були проведені під керівництвом професора Лапшина В.І. та продемонстровані «освіченим» харків'янам, вивчені теплова дія електричного струму і особливості електролізу деяких неорганічних та органічних речовин. Було також отримано електричну дугу, вивчено її спектр та поляризацію її світла, проведено фотографування різних предметів у оптичному мікроскопі з використанням світла електричної дуги. Були також проведені досліди, спрямовані на проведення освітлення світлом електричної дуги фізичного кабінету, святкової зали університету, Лопанського мосту та Залопанської території. На прохання відомого німецького фізіолога професора Людвіга Будге були проведені дослідження, в яких вивчався вплив фізіологічної дії електричного струму на організм людини. Низку гальванічних дослідів було представлено Імператору Олександру II 17 вересня 1859 р. під час відвідування ним Імператорського Харківського університету.

Результати гальванічних дослідів були опубліковані В.І. Лапшиним у 1859 р. у журналі «Вестник естественных наук», (№37-39). Про них також писали Харківські газети. Про результати досліджень було повідомлено і у журналі «Annalen der Physik und Chemie» за 1860 рік.

October 23

Физика в математике. О преподавании математики на физическом факультете

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Программы по математике на физическом факультете включают необходимый материал по важнейшим разделам широкого спектра математических дисциплин. Иногда изложение этих разделов носит относительно формальный характер. Это естественно, поскольку содержание математического аппарата наиболее полно может быть раскрыто в тех специальных дисциплинах, которые его используют.

Однако такое "разделение труда" при чтении математики на физическом факультете постоянно порождает у студентов немой вопрос "зачем это нужно". Представляется разумным получаемый математический аппарат иллюстрировать по мере возможности физическими приложениями.

В математическом анализе нахождение кратных интегралов формулируется, как нахождение массы/заряда, центра масс (тела, поверхности, кривой), работы силы (гравитации, упругости), потока (жидкости, заряда). В линейной алгебре проводится связь между самосопряженностью операторов и сохранением энергии замкнутой физической системой, что исподволь готовит студентов к восприятию "кошмара" квантовой механики. Многочисленные интегральные теоремы векторного анализа поясняются примерами из различных разделов физики, в частности, электродинамики при анализе электростатического и магнитостатического полей. Подробно исследуются тензоры угловой скорости, инерции, деформации, напряжений с выяснением их физического смысла.

Такое проникновение физики в математику плодотворно сказывается на понимании студентами-физиками абстрактного математического аппарата, воспринимая его чуть ли не как разделы физики.

November 27

Екзопланети: від відкриття до пошуку біомаркерів

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С момента открытия первой планеты у солнцеподобной звезды в 1995 году до настоящего времени открыто более 4100 планет у других звезд. Среди них 670 систем с более чем двумя планетами.

Изучение свойств экзопланет - самая быстро развивающаяся область астрофизики. После измерения радиусов и масс на первом этапе исследований, удалось получить первые прямые изображения планет, теперь уже стало возможным определять наличие некоторых молекул в их атмосферах. В дальнейшем станет доступным измерение магнитных полей газовых гигантов и открытие спутников у экзопланет. Кроме того, значительное число планет открыто у относительно ярких звезд и уточнение периодов обращения планет вокруг этих звезд возможно из наблюдений на достаточно скромных телескопах.

В докладе планируется ознакомить с методами открытия и исследования планет и проанализировать основные свойства и состав атмосфер обнаруженных планет.

Также кратко будет рассказано о работах, за которые была присуждена Нобелевская премия по физике за 2019 год.

December 18

Nonlinear electromagnetic phenomena in layered superconductors

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The results of the research on the nonlinear electromagnetic phenomena in the structures containing the layered superconductors are reported. A special type of solid-state plasma, called the Josephson plasma, is formed in such superconductors. This plasma is strongly anisotropic and nonlinear, because of the nonlinear Josephson relation between the superconducting current and interlayer phase difference. In such a plasma, the so-called Josephson plasma waves can propagate at THz frequency range, which provide some non-trivial phenomena. Among them are the self-induced transparency, nonlinear transformation of polarizations, nonlinear impact of dc magnetic field on linear electromagnetic waves, and anomalous dispersion of localized waves. In particular, the nonlinear effect of the self-induced transparency of the layered superconductor slab irradiated by the terahertz wave is predicted. It is shown theoretically that the transparency changes widely from the almost opacity to the total transparency varying the amplitude of the incident wave. An analogue of the superposition principle for the nonlinear Josephson plasma waves has been formulated. The use of this principle allows to study theoretically the nonlinear transformation of polarization. The effect of dc magnetic field on the propagation of electromagnetic waves are investigated. The possibility to control the transport characteristics of the layered superconductors by means of such a magnetic field are discussed. The dispersion relations for the linear and nonlinear electromagnetic modes localized on a plate of a layered superconductor are obtained and analyzed. it is shown that such modes may have anomalous dispersion over a wide range of parameters. The reported results supplement and extend the existing conceptions of the electromagnetic transport in the layered superconductors, and can be used for the development of the terahertz electronic devices potentially important for the practical application.

Keywords: Josephson effect, layered superconductor, terahertz frequency range, polarization, localized waves.