Министерство образования и науки Украины
Севастопольский национальный технический университет

Последние достижения в области физики = Latest Developments in Physics

МЕТОДИЧЕСКИЕ УКАЗАНИЯ
к практическим занятиям по дисциплине
"Английский язык" для студентов II курса
специальности «Физика» дневной формы обучения
и продвинутого этапа обучения (ФОП)

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Последние достижения в области физики = Latest Developments in Physics. Методические указания к практическим занятиям по дисциплине «Английский язык» для студентов II курса специальности «Физика» дневной формы обучения и продвинутого этапа обучения (ФОП) / Сост. Р.В. Камышников. – Севастополь: Изд. СевНТУ, 2010. – 36 с.

Методические указания предназначены для самостоятельной работы студентов на II курсе. Их целью является привитие навыков чтения, понимания и перевода литературы по специальности, обучения активному владению языковым материалом, ведению беседы на английском языке в пределах рассматриваемых тем, ознакомление с последними достижениями ученых ведущих стран в области физики.

Методические указания рассмотрены и утверждены на заседании кафедры ПРГЯ (протокол №_ от 2010 г.).

Допущено учебно-методическим центром СевНТУ в качестве методических указаний.

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СОДЕРЖАНИЕ

ВВЕДЕНИЕ

Методические указания предназначены для практических занятий по английскому языку студентов II курса специальности «Физика» дневной формы обучения, а также студентов специальности «Физика» продвинутого этапа обучения.

Цель методических указаний заключается в подготовке студентов к пониманию научно-технических текстов по специальности, систематизации и обобщении лексического материала, обучении монологической речи, а также ведении бесед на тему последних достижений в области физики.

Методические указания состоят из восьми уроков, каждый из которых включает тексты для чтения, перевода и последующего пересказа и обсуждения, лексические упражнения, задания, связанные с активизацией устной речи студентов. Программу завершает итоговый тест, направленный на проверку усвоения информации и лексики, содержащейся во всех восьми уроках.

Система упражнений на предтекстовом, текстовом и послетекстовом этапах работы направлена на усвоение специальной лексики, формирование навыков профессиональной устной речи, развитие свободной ориентации в текстах по специальности.

LESSON 1.
DISCOVERY OF LATERAL REPULSIVE FORCE OF LIGHT

Words and word combinations:

applied sciences – прикладные науки
repulsive effect – отталкивающее действие
to crown with – завершить (чем-л.)
nanodimensional – наноразмерный
waveguide – волновод
nanophotonics – нанофотоника
lateral force of light – боковая сила света
frontal light pressure – фронтальное давление света
optical binding forces – оптические связывающие силы
magnetic – притягивающий
adjacent – соседний
to capture – захватывать, ловить
at the request – по желанию
quantum fluctuation – квантовое колебание
to disjoint – разделить
loop – петля
to dislocate phase – смещать фазу
to transmit – передавать
character – *зд.* знак плюс или минус
regularities – закономерности
to draw – притягивать
economically-attractive – экономичный

TEXT

In July 2009, the American scientist of Chinese origin Dr. Hong Tang and his team from Engineering and Applied Sciences School, Yale University, experimentally discovered the repulsive effect of light. With this, they crowned the image of bipolar interaction of near-located nanodimensional waveguides, where certain radiation beams pass.

In 2008, Dr. Tang and his colleagues combined such two sciences as nanomechanics and nanophotonics (branch of nanooptics that deals with the light reaction in nanodimensions), and created the device to control the position of components with the help of lateral force of light perpendicular to the beam. However, this interaction of electromagnetic waves and optical system should not be mixed up with the frontal light pressure to the surface of any object, discovered in the beginning of the XX century.

Theorists all over the world predicted the existence of lateral forces, or optical binding forces, since 2005, and it was supposed that they might be either repulsive, or magnetic. The latter forces were discovered last year. And now the same group of scientists constructed the microscopic device to demonstrate not only magnetic effect, but also repulsive forces between two adjacent light beams captured inside the waveguides. Moreover, the physicists found the way of forces regulation at their request.

The scientists actually proved the existence of bipolar force of light with repulsive and magnetic components. In their explanation, optical binding forces are linked with Maxwell equations, and in their physical essence the above stated forces are relatives of Casimir force, which appears owing to quantum fluctuation in the vacuum.

To show the new force, scientists disjointed the infra-red laser beam into two separate streams in silicon waveguides with different length. In the end of that loop the waveguides came close to each other (the distance was changed in the number of experiments). In that moment two adjacent beams dislocated their phases relatively to each other.

The experimenters found out that subject to the value of the dislocation the lateral force of beams interaction they transmitted to their waveguides, also changed in value and in character. Though the force was only a few piconewtons in its value, the physicists managed to measure it and recognize its regularities. Thus, the new force depended on the phases dislocation, radiation power, and distance between waveguides.

Dr. Wolfram Pernice, one of the authors of the experiment, stated that the forces of light interaction intrigued scientists as they worked in the opposite way to the charged objects. The contrary charges draw each other, and the light beams with dislocated phases are repulsed.

Dr. Tang's collaborators consider their technology is necessary in production of prompt, compact and economically-attractive telecommunication devices. In such circuits, components might interact with each other owing to the light captured in waveguides. So, in future this method will reduce the number of conductors greatly.

1. Answer the following questions:

1) When did Dr. Tang's team create the device to control the position of components?
2) What experiment took place in Yale University in July 2009?
3) Who predicted the existence of optical binding forces?
4) State the aim of creation of the microscopic device by the group of scientists.
5) How are optical binding forces connected with Casimir force?
6) In what way did scientists show the new force?
7) Describe the changes of the lateral force.
8) Why do the scientists think the forces of light interaction intrigue them?
9) What is the future application of the above stated discovery?

2. Use the correct words from the text:
1) Scientists constructed the microscopic device to demonstrate not only … effect, but also … forces between two light beams captured inside the waveguides.
2) With this, they crowned the image of bipolar … of near-located nanodimensional waveguides, where certain … beams pass.
3) The light beams with … phases are repulsed.
4) Physicists predicted the existence of lateral forces, or … … forces.
5) The technology is necessary in production of …, compact and … telecommunication devices.
6) Though the force was only … piconewtons in its value, the physicists … to measure it.

3. True or false?
1) The frontal light pressure to the surface of any object was discovered in the beginning of the XIX century.
2) The physicists proved the existence of bipolar force of light with magnetic components.
3) Dr. Tang stated that the forces of light interaction intrigued scientists greatly.
4) Nanophotonics is the branch of nanomechanics.
5) The new force depended on the phases dislocation, and distance between waveguides only.
6) In future the technology will be used in production of compact telecommunication devices.
7) Two adjacent beams dislocated their phases relatively to each other in the end of the loop.
8) Optical binding forces are linked with Maxwell equations.
9) The lateral force of beams interaction was a few micronewtons in its value.

4. Match words with their meanings:

1) science	a) unit of force
2) device	b) putting to a special or practical use
3) repulsion	c) something thought out or invented for a special purpose
4) prompt	d) ray or stream of light from any object
5) equation	e) acting or done without delay
6) newton	f) knowledge arranged in an orderly manner
7) beam	g) statement of equality between two expressions
8) application	h) tendency of bodies to repel each other

5. Translate from Russian into English:
1) По физической сути данные силы являются родственниками силы Казимира, которая появляется из-за квантовых колебаний в вакууме. 2) Один из авторов эксперимента считал, что силы взаимодействия света интригуют, поскольку работают противоположным образом по сравнению с заряженными

телами. 3) Доктор Хун Тан и его коллеги построили устройство, в котором для контроля положения компонентов применялась боковая сила воздействия со стороны света, перпендикулярная лучу. 4) Компоненты могут взаимодействовать друг с другом без применения проводников. 5) Для проявления этой новой силы учёные разделили луч инфракрасного лазера на два отдельных потока. 6) Боковая сила взаимодействия пучков меняется в зависимости от величины их сдвига по фазе. 7) Учёным удалось измерить новую силу и установить ряд её зависимостей. 8) Результаты экспериментального открытия могут применяться в производстве быстрых и экономичных коммуникационных устройств. 9) Близко расположенные наноразмерные волноводы использовались для определения свойств новой силы света. 10) Если бы эксперимент команды Тана провалился, учёные повторили бы его после усовершенствования своей теории.

6. Discuss the following topics:
1) Further possibilities of lateral repulsive force of light.
2) Use of modern physical discoveries in production.
3) Other economically-attractive propositions from modern physicists.

LESSON 2.
QUASI-THREE-DIMENSIONAL ELECTRONIC CRYSTAL

Words and word combinations:

fundamentally – принципиально
quasi-three-dimensional – квазитрехмерный
to entail – приводить к (чему-л.)
speeding-up – ускорение
uncommonness – необычность
genuine – настоящий
intermediate area – промежуточная среда
to place under – привести в соответствие с (чем-л.)
two-dimensional – двумерный
to squeeze – протискиваться
in plane – в плоскости
ultra low – сверхнизкий
intergalactic space – межгалактическое пространство
neodymium – неодим (химический элемент)
boron – бор
positive in mind – убежденный
inexpensively – экономно
to evade – обойти, избежать

TEXT

A year ago the Canadian physicists of McGill University, Montreal, headed by Dr. Guillaume Gervais, discovered fundamentally new state of substance and named it quasi-three-dimensional electronic crystal. Such a phenomenon occurs owing to the strong influence of magnetic field upon a cooled semiconductor. This discovery may entail the speeding-up of electronics development.

The real uncommonness of the discovery is that this state of substance is not genuine three-dimensional one. It represents intermediate area, and the new task for theorists now is to place the available models under the present situation. The discovery originates from the so-called two-dimensional electronic crystal received on the basis of numerous experiments of the Canadian scientists in 1990s.

To understand the principle of the two-dimensional electronic crystal, let's imagine a sandwich with electrons instead of ham. In such a system the electrons squeeze between two materials, so the crystal is named two-dimensional. The electrons may move in plane only, like billiard-balls on the surface of the table. They have certain thickness, but it is impossible for them to move up and down.

In new experiment the scientists cooled the two-dimensional electronic crystal up to the ultra low temperature, 100 times lower than the temperature of intergalactic space that makes minus 270 degrees Celsius. Then the material was placed to the magnetic field produced by the most powerful magnet in the world in the US National Laboratory, Florida. The magnet is made of the alloy of neodymium, iron, and boron that are considered to be the most suitable magnetics. As a result, the electrons received new ability to move in earlier prohibited directions, and the two-dimensional system inside the semiconductor transformed into the quasi-three-dimensional one.

The scientists are positive in mind that their discovery may result in a new stage of electronics development. Particularly, it will allow preserving the effect of Moore's Law. According to it, the number of transistors that can be placed inexpensively on an integrated circuit has doubled approximately every two years owing to the decrease of their dimensions. The only disadvantage is that the physical properties of transistors change on reaching nanodimensions, and Moore's Law ceases its effect. The quasi-three-dimensional electronic crystal will give the chance to evade such limitations.

1. Answer the following questions:

1) When did the Canadian scientists make the important discovery and what was its core?

2) What is the unordinariness of the discovery?

3) How can we understand the principle of the two-dimensional electronic crystal?

4) The temperature used in new experiment was -270 degrees Celsius, wasn't it?

5) Name the components of the alloy for the most powerful magnet. Why did the scientists use just them?

6) What is the disadvantage of Moore's Law?
7) Why are the scientists positive in mind that their discovery will give the chance to evade Moore's Law limitations?

2. Use the correct words from the text:
1) The electrons received new ability to move in … … directions.
2) It takes place owing to the strong influence of … field upon a … semiconductor.
3) The number of … has doubled approximately every two years.
4) Scientists cooled the … electronic crystal up to the … temperature.
5) The … may move in plane only.
6) The only … is that their physical properties change on reaching ….

3. True or false?
1) The quasi-three-dimensional crystal will give the opportunity to avoid some limitations.
2) In all physical systems the electrons usually squeeze between two materials.
3) In 1990s scientists cooled the two-dimensional electronic crystal up to the ultra low temperature.
4) New discovery may entail the speeding-up of chemistry development.
5) The very powerful magnet is made of the alloy of some metals.
6) Some scientists are negative in mind concerning the discovery.
7) Dr. Gervais was the head of the group of researchers from the USA.
8) It is impossible for the electrons to move to the left and to the right.
9) Nanodimensions influence the physical properties of transistors.

4. Match words with their meanings:

1) electron	a) factual statement of what always happens in certain circumstances
2) dimension	b) substance able to attract iron
3) law	c) new stage which is the result of some activity
4) crystal	d) particle of matter, smaller than an atom, with a negative electric charge
5) magnet	e) small electronic device used in different kinds of electronic apparatus
6) circuit	f) definite and regular shape taken naturally by the molecules of some substances
7) development	g) measurement of any sort
8) transistor	h) closed path for an electrical current

5. Translate from Russian into English:
1) Недавно физики открыли принципиально новое состояние материи, о котором не упоминалось ранее. 2) Теоретики собираются привести в соответствие с новым открытием стандартные ситуации. 3) Несмотря на то,

что электроны имеют определенную толщину, они могут двигаться только в плоскости. 4) Ученые охладили двумерный электронный кристалл до сверхнизкой температуры, в 100 раз ниже температуры межгалактического пространства. 5) По словам ученых, это открытие может привести к новому этапу в развитии электроники. 6) Согласно закону Мура, количество транзисторов на кристалле удваивается каждые два года за счет уменьшения их размеров. 7) Доктор Гийом Жерве использовал в своем эксперименте крупнейший в мире магнит, изготовленный из сплава нескольких металлов. 8) Промежуточная среда может быть выявлена в лабораторных условиях при наличии определённого оборудования. 9) Если сильное магнитное поле воздействует на охлажденный полупроводник, это приводит к появлению квазитрехмерного электронного кристалла. 10) Ускорение развития электроники напрямую зависит от последних достижений ученых в области физики.

6. Discuss the following topics:
1) Moore's Law and its consequences.
2) New generations of crystals.
3) Use of the most powerful magnets all over the world.

LESSON 3.
ATOMIC CHANGES IN NANOWIRES

Words and word combinations:

nanowire – нанопроводник, нанонить
parity – равенство
ferromagnetic – ферромагнитный
logic gates – логические ворота (компьютерная функция on/off)
odd numbers – нечетные числа
even numbers – четные числа
incredible – немыслимый
reversible – обратимый
frustration – *зд.* невосприятие
suspended – подвешенный
substrate – основание
fragile – хрупкий
Density Functional Theory – функциональная теория плотности
tuning – настройка
to succeed in – преуспевать в (чем-л.)
perturbation – волнение, колебание
chiral nanostructure – хиральная наноструктура

(неспособная к накладыванию на другую структуру)
to stop short – останавливаться на достигнутом

TEXT

Adding just a single atom to a nanowire, or taking one away from it, can completely change the wire's magnetic properties. So think researchers of the Institut für Festkörperforschung, Jülich, Germany, who have modelled the effect of atom parity on antiferromagnetic wires placed on a ferromagnetic surface, in 2008. The phenomenon, unique to nanostructures, might one day be used in computer science and electronics.

Adding or removing one atom from a solid containing about 10^{23} atoms does not make much of a difference, but this is not the case in nanostructures. Here, the magnetic structure changes dramatically across the entire nanowire depending on whether the total number of atoms in the wire is odd or even.

Changing the parity of a wire by adding or subtracting a single atom leads to such incredible effect as a switch of the magnetic behaviour from one state to a completely different one. This peculiar nano-effect does not occur in micro- or macrostructures and is totally reversible.

The effect occurs thanks to "frustration": for example, when a suspended antiferromagnetic wire is put on a ferromagnetic surface, there is a frustration between the local antiferromagnetic structure and the underlying ferromagnetic substrate. This is because neighbouring atoms in the wire prefer to couple antiferromagnetically, but are prevented from doing so by the substrate. In such a system, the magnetic interaction between neighbours is strong, but the magnetic structure as a whole is fragile and small changes to it can make a big difference.

Picture 1. Principle of atomic frustration

The researchers obtained their results using quantum-chemical computer simulations based on Density Functional Theory (for which the American scientist Walter Kohn and his British colleague John Pople received the 1998 Nobel Prize in Chemistry). This type of calculation relies only on the basic laws of quantum mechanics without additional parameters.

By tuning the strength of the magnetic interaction within the wire and between the wire and a surface, the co-workers succeeded in constructing a phase diagram from which they predicted where the parity effect occurred on a wire length.

The effect is nothing else but a magnetic switch between two different magnetic states switched by the addition or removal of an atom. In hard disks, the

magnetic information is stored in binaries (0) and (1) that can be represented by the two magnetic solutions found in these nanowires.

The behaviour observed in the simulations could also be useful for building logic gates made of magnetic wires. This is because perturbations at the edge of the wire travel along the whole wire until they reach the other side.

The team of the scientists is not going to stop short and is now planning to look at chiral magnetic nanostructures deposited on surfaces.

1. Answer the following questions:
1) How can scientists change the wire's magnetic properties?
2) How can the parity of a wire be changed?
3) Characterize the switch of the magnetic behaviour.
4) Why does frustration take place in producing the above stated effect?
5) Who received the Nobel Prize for Density Functional Theory?
6) How did scientists construct a phase diagram? And what for?
7) Where is magnetic information usually stored?
8) What is the possible application of the effect of atom parity?
9) What is the team's future sphere of interest?

2. Use the correct words from the text:
1) The magnetic structure as a whole is … and small changes to it can make a big ….
2) The … is nothing else but a magnetic … between two different magnetic states.
3) Adding an atom to a … can completely change the wire's … properties.
4) The calculation relies only on the basic laws of … … without additional parameters.
5) The magnetic structure changes … across the … nanowire.
6) The … obtained their results using quantum-chemical … simulations.

3. True or false?
1) The team of scientists is now going to stop short.
2) The process of frustration takes place when a suspended antiferromagnetic wire is put on a ferromagnetic surface.
3) The American scientists Walter Kohn and John Pople received the 1998 Nobel Prize in Chemistry.
4) In hard disks, the magnetic information is stored in binaries.
5) Adding or removing one atom from a solid of about 10^{23} atoms makes much of a difference.
6) It was the phase diagram that helped scientists in predicting where the parity effect occurred on a wire length.
7) In nanostructures the magnetic structure changes drastically across the entire nanowire.

8) Density Functional Theory was used as the base for quantum-chemical computer simulations.
9) The above stated nano-effect may occur in macrostructures and is totally reversible.

4. Match words with their meanings:

1) diagram	a) general law of cause and effect
2) principle	b) not exactly divisible by two
3) simulation	c) reasoned account offered to explain facts or events
4) phenomenon	d) design or plan to illustrate or explain something
5) odd	e) treatment shown towards other things or objects
6) solution	f) thing that is known to exist by the senses
7) theory	g) process of finding an answer or explanation
8) behaviour	h) pretence or imitation used to prove or disapprove an assumption

5. Translate from Russian into English:
1) Сэмиру Лунису и его коллегам из города Юлиха в рамках математической модели удалось наблюдать изменение магнитных свойств нанопроводника всего одним атомом, помещенным на его поверхность. 2) Немецкие ученые детально изучили этот удивительный эффект и уверены, что в будущем он поможет нанотехнологам в их работе. 3) Магнитные свойства нанопроводника напрямую зависят от числа атомов в его составе. 4) Подобный эффект полностью обратимый, поскольку удаление атома ведет к возвращению прежних магнитных свойств нанопроводника. 5) Этот эффект не наблюдался в микроструктурах, но в нанометровом диапазоне длин проявлялся постоянно. 6) Физики использовали функциональную теорию плотности, чтобы подтвердить свои предположения. 7) Состояние нанопроводников можно контролировать изменением их атомной длины. 8) В будущем нанонити смогут стать ещё одним хранилищем информации. 9) Если бы исследователи не использовали ферромагнитную поверхность для антиферромагнитных проводников, они бы не узнали об эффекте атомного невосприятия. 10) Моделирование в области нанотехнологии сегодня является наиболее интересным направлением для ученых крупнейших мировых университетов.

6. Discuss the following topics:
1) Modern researches of the German physicists.
2) Nanotechnologies in our life.
3) The recent Nobel Prize winners in Physics.

LESSON 4.

NASA: SPACE TELESCOPE MISSION

Words and word combinations:

to host – принимать
to blast – запускать
NASA (National Aeronautics and Space Administration) –
НАСА (Национальное агентство по аэронавтике и исследованию космического пространства)
to orbit – двигаться по орбите
essential – основной элемент
ultimately – в конечном счёте
census – сбор данных
to survey – исследовать
Cygnus-Lyra – созвездия Лебедь и Лира
Milky Way – Млечный Путь
habitable – пригодный для жизни
to imply – подразумевать
dimming – мерцание
to wink – мерцать
faint – слабый
array – комплекс, набор
charge-coupled device (CCD) – прибор с зарядовой связью (ПЗС)
porch – крыльцо
patch – зона, участок
to stare – вглядываться
multiple – повторяющийся
corner-stone – краеугольный камень
emerge – появляться
exoplanet = extrasolar planet – планета вне Солнечной системы
to chart course – прокладывать курс

TEXT

In spring 2009, NASA's Kepler spacecraft began a journey to search for worlds that could potentially host life.

Kepler, a NASA space telescope named in honour of German astronomer Johannes Kepler, was blasted into space from Cape Canaveral Air Force Station, Florida, aboard a Delta II rocket, on March 7 at 10:48 p.m. It is the first mission with the ability to find planets like Earth – rocky planets that orbit sun-like stars in a warm zone where liquid water could be maintained on the surface. Liquid water is believed to be essential for the formation of life.

Kepler is a critical component in NASA's efforts to ultimately find and study planets where Earth-like conditions may be present. The planetary census Kepler takes will be very important for understanding the frequency of Earth-size planets in our galaxy and planning future missions that directly detect and characterize such worlds around nearby stars.

The mission will spend three and a half years surveying more than 100,000 sun-like stars in the Cygnus-Lyra region of our Milky Way galaxy. It is expected to find hundreds of planets the size of Earth and larger at various distances from their stars. If Earth-size planets are common in the habitable zone, Kepler could find dozens; if those planets are rare, Kepler might find none.

In the end, the mission will be the first step toward answering a question posed by the ancient Greeks: are there other worlds like ours or are we alone?

As NASA's Research Center scientists think, finding that most stars have Earths implies that the conditions that support the development of life could be common throughout our galaxy. Finding few or no Earths indicates that we might be alone.

The Kepler telescope is specially designed to detect the periodic dimming of stars that planets cause as they pass by. Some star systems are oriented in such a way that their planets cross in front of their stars, as seen from our Earthly point of view. As the planets pass by, they cause their stars' light to slightly dim, or wink.

The telescope can detect even the faintest of these winks, registering changes in brightness of only 20 parts per million. To achieve this resolution, Kepler will use the largest camera ever launched into space, a 95-megapixel array of charge-coupled devices, known as CCDs.

If Kepler were to look down at a small town on Earth at night from space, it would be able to detect the dimming of a porch light as somebody passed in front.

By staring at one large patch of sky for the duration of its lifetime, Kepler will be able to watch planets periodically transit their stars over multiple cycles. This will allow astronomers to confirm the presence of planets. Earth-size planets in habitable zones would theoretically take about a year to complete one orbit, so Kepler will monitor those stars to confirm their presence.

Kepler is a critical corner-stone in understanding what types of planets are formed around other stars. The discoveries that emerge will be used immediately to study the atmospheres of large, gas exoplanets with the space telescope named Spitzer. And the statistics will help scientists chart a course toward one day imaging a pale blue dot like our planet, orbiting another star in our galaxy.

1. Answer the following questions:
1) What is Kepler?
2) Characterize the Earth-like planets.
3) What is the aim of finding planets like Earth?
4) Why will the planetary census Kepler takes be very important?
5) When is the mission predicted to come to the end?

6) Who seems to think optimistically about life conditions throughout our galaxy?
7) What the Kepler telescope is designed for?
8) How can the telescope register changes in brightness?
9) Give the Earthly example of Kepler's usage.
10) How do scientists use the Spitzer telescope?

2. Use the correct words from the text:
1) Kepler is a critical … in understanding what types of … are formed around other stars.
2) Kepler will use the largest camera ever launched into space, an array of …-… …, known as ….
3) It is expected to find hundreds of planets the size of … and larger.
4) Kepler was blasted into space from … … Air Force Station, aboard a Delta II ….
5) As the … pass by, they cause their stars' light to slightly …, or wink.
6) Finding few or no … indicates that we might be alone.

3. True or false?
1) Vaporous water is believed to be essential for the formation of life.
2) The statistics will help scientists chart a course towards the second Earth.
3) The telescope can register changes in brightness of only 10 parts per million.
4) The mission will survey about 100,000 sun-like stars in the Cygnus-Lyra region of our galaxy.
5) Now we cannot answer the question posed by the ancient Greeks: are there other worlds like ours or are we alone?
6) Finding no Earths indicates that we might live with extraterrestrials.
7) The discoveries that emerge will be used to study the atmospheres of large, gas exoplanets.
8) In autumn 2006, NASA's spacecraft began its scientific journey.
9) CCD is the abbreviation for a charge-coupled device.

4. Match words with their meanings:

1) spacecraft	a) any of the huge groups of stars in outer space
2) planet	b) series of events taking place in a regularly repeated order
3) galaxy	c) forward movement in space or time
4) mission	d) path followed by a heavenly body round another body
5) cycle	e) body seen in the sky at night as a distant point of light
6) star	f) apparatus used for travel beyond the Earth's atmosphere
7) orbit	g) special task assigned to an individual or a group
8) course	h) heavenly body which moves round a star such as the Sun

5. Translate from Russian into English:
1) Миссия телескопа предусматривает просмотр более 100 тысяч звёзд за следующие три с половиной года, поэтому шанс на успех велик. 2) Точность

измерения яркости планет у этого аппарата в пять раз лучше, чем у предыдущей модели. 3) Теоретически, планеты размером с Землю в пригодных для жизни зонах проходят по своей орбите примерно за один год. 4) Если миссия «Кеплера» завершится благополучно, ученые смогут ответить на вопрос, который сформулировали ещё древние греки. 5) Когда физики стали использовать приборы с зарядовой связью, они решили применить их в крупнейших электронных оптических приборах. 6) Исследовательский центр НАСА провел грандиозную работу в поисках новых галактик, которые походили бы на наш Млечный Путь. 7) Телескоп «Спитцер» используется для изучения больших планет, которые не входят в Солнечную систему. 8) В задачи миссии входит исследование более ста тысяч похожих на Солнце звёзд в области созвездий Лебедь и Лира нашей галактики. 9) Интересен тот факт, что «Кеплер» сможет также фиксировать планеты намного крупнее Земли. 10) Телескоп последнего поколения легко почувствует ослабление яркости планеты всего на одну десятитысячную долю.

6. Discuss the following topics:
1) Current achievements of the Kepler mission.
2) Charge-coupled devices and their application.
3) History of telescopes.

LESSON 5.
DARK MATTER. PRESENT-DAY VIEWPOINT

Words and word combinations:

dark matter – скрытая масса, тёмная материя
undetectable – недоступный прямому наблюдению
to infer – подразумевать
elusive – уклончивый
to discredit – опровергнуть
ether – эфир (среда, которая заполняет пространство между Солнцем и планетами)
to overturn – отменять, опровергать
inconsistency – несоответствие
approximation – приближенное значение
Modified Newtonian Dynamics – модифицированная ньютоновская динамика
to adjust – корректировать
to reconcile – согласовывать
lensing – фокусировка
deflection – преломление
Tensor-Vector-Scalar – тензорно-векторно-скалярная теория

colliding – сталкивающийся
cluster – скопление
Nonsymmetric Gravitational Theory – теория несимметрической гравитации
boson – бозон (элементарная частица)
fermion – фермион (элементарная частица)
active neutrinos – активные нейтрино
sterile neutrinos – неактивные нейтрино

TEXT

As we know from astronomy and cosmology, dark matter is a hypothetical form of matter that is undetectable by its emitted electromagnetic radiation, but whose presence can be inferred from gravitational effects on visible matter. According to present observations of structures larger than galaxies, dark matter and dark energy could account for the vast majority of the mass in the observable universe.

Dark matter and dark energy represent the most popular theory among physicists and cosmologists to explain the various anomalies observed earlier. However, direct observational evidence of dark matter has remained elusive. A minority of scientists have suggested that the existence of a vast amount of undetected matter is less likely than the possibility that current theories of gravitation are simply incomplete (much like the now discredited theory of ether, once thought to be the medium through which light travels, but overturned in the early 20^{th} century).

A proposed alternative to physical dark matter particles has been to suppose that the observed inconsistencies are due to an incomplete understanding of gravitation. To explain the observations, the gravitational force has to become stronger than the Newtonian approximation at great distances or in weak fields. One of the proposed models is Modified Newtonian Dynamics (MOND), which adjusts Newton's laws at small acceleration. However, constructing a relativistic MOND theory has been troublesome, and it's not clear how the theory can be reconciled with gravitational lensing measurements of the deflection of light around galaxies.

The leading relativistic MOND theory, proposed by the Jewish physicist Jacob Bekenstein in 2004 is called TeVeS for Tensor-Vector-Scalar and solves many of the problems of earlier attempts.

However, a study in August 2006 reported an observation of a pair of colliding galaxy clusters whose behaviour was not compatible with any current modified gravity theories.

In 2007, John W. Moffat, Danish physicist, proposed a theory of modified gravity (MOG) based on Nonsymmetric Gravitational Theory (NGT, a classical theory of gravitation which tries to explain the observation of the flat rotation curves of galaxies) that claims to account for the behaviour of colliding galaxies. This

theory still requires the presence of non-relativistic neutrinos (another candidate for dark matter) to work: modified gravity alone is not sufficient.

In 2009 the Dutch physicist Theo M. Nieuwenhuizen analyzed the lensing data of the galaxy cluster Abell 1689, assuming that its dark matter is described by an isothermal profile of quantum particles. Bosons do not fit the data. Fermions should have mass of a few eV, quite light, so it would explain why the many dark matter searchers have failed. This approach explains the temperature, the radial profile and the reionization of the cluster gas. The best case is provided by neutrinos of about 1.5 eV. Active ones alone account for some 9.5% dark matter, so sterile ones with similar mass are needed to achieve about 19%. This would lead back to the dark matter scenario, which requires a new explanation of structure formation.

1. Answer the following questions:
1) How can you describe the dark matter?
2) What is the main difficulty in observation of the dark matter?
3) What was the theory discredited in the early 20th century?
4) Show the reason of the inconsistencies in the proposed alternative of the dark matter theory.
5) What was the drawback in constructing a relativistic MOND theory?
6) Who proposed TeVeS, and when?
7) Interpret the abbreviation MOG.
8) What is Nonsymmetric Gravitational Theory?
9) How could Theo M. Nieuwenhuizen argue his approach concerning the dark matter?
10) What is the percentage rate between the active and sterile neutrinos?

2. Use the correct words from the text:
1) The best … is provided by … of about 1.5 eV.
2) Constructing a … … theory has been troublesome.
3) Theo M. Nieuwenhuizen analyzed the … data of the galaxy … Abell 1689.
4) Dark matter and … … could account for the vast majority of the mass in the … uiverse.
5) The behaviour of colliding … clusters was not … with any current modified gravity ….
6) Such an approach explains the …, the radial … and the … of the cluster gas.

3. True or false?
1) Dark matter is a hypothetical form of matter that is detectable by its emitted electromagnetic radiation.
2) The presence of dark energy can be inferred from gravitational effects on visible matter.
3) Theory of ether, once thought to be the medium through which light travels, was discredited in the early 20th century.

4) To explain the observations, the gravitational force must be stronger than the Newtonian approximation in weak fields.
5) MOND is a theory of modified gravity.
6) Jacob Bekenstein proposed Nonsymmetric Gravitational Theory in 2004.
7) NGT is a classical theory of gravitation which tries to explain the observation of some parts of galaxies.
8) In our case, bosons don't fit the data.
9) Active neutrinos account for some 19.5% dark matter.

4. Match words with their meanings:

1) deflection	a) number of objects in a small closed group
2) cluster	b) something different from the usual type
3) matter	c) line of which no part is straight like part of the edge of a circle
4) anomaly	d) written outline with details
5)approximation	e) turning aside or moving in a different direction
6) curve	f) substance of which a physical thing is made
7) scenario	g) one of more than two possibilities
8) alternative	h) almost correct amount or estimate

5. Translate from Russian into English:
1) Скрытая масса рассматривается многими учёными в качестве гипотетической формы материи, которая недоступна прямому наблюдению из-за отсутствия электромагнитного излучения. 2) Последние наблюдения за структурами, которые по размерам больше галактик, показали, что скрытая масса и скрытая энергия заполняют бóльшую часть пространства во вселенной. 3) В начале XX века учёные опровергли теорию эфира, согласно которой эфир являлся средой для перемещения световых лучей. 4) Относительная теория модифицированной ньютоновской динамики не была согласована с явлением преломления света в галактиках. 5) Тензорно-векторно-скалярная теория помогла исследователям решить все проблемы, которые ранее представляли значительные трудности. 6) Новая трудность возникла в результате наблюдений за сталкивающимися скоплениями галактик, чьё поведение не было описано ни одной из теорий. 7) Классическая теория несимметрической гравитации является основой теории модифицированной гравитации. 8) Проанализировав данные фокусировки определённого скопления галактик, учёные смогли описать скрытую массу в рамках изотермического профиля квантовых частиц. 9) Если бы бозоны и фермионы подходили для исследований по своим параметрам, физики доказали бы намного больше теорий скрытой массы. 10) Активные и неактивные нейтрино в процентном соотношении составляют 28,5% скрытой массы.

6. Discuss the following topics:
1) Physical cosmology as a branch of astronomy.
2) Galaxy clusters and gravitational lensing.
3) Dark matter in fiction.

LESSON 6.
LARGE HADRON COLLIDER

Words and word combinations:

Large Hadron Collider (LHC) – большой адронный коллайдер
lead nuclei – ионы свинца
circumference – длина окружности
concrete – бетон
Large Electron-Positron Collider – большой электрон-позитронный коллайдер
ancillary – вспомогательный
European Organization for Nuclear Research (CERN) –
Европейская организация по ядерным исследованиям (ЦЕРН)
supersymmetry – суперсимметрия (физическая гипотеза строения вещества)
to halt – останавливать
superconducting bending magnet – сверхпроводящий изогнутый магнит
injection energy – впускная энергия
commissioning run – ввод в эксплуатацию
bunch – пучок, сгусток (электронов, протонов)
intersection – смежная область, место соприкосновения
luminosity – яркость

TEXT

The Large Hadron Collider (LHC) is the world's largest and highest-energy particle accelerator, intended to collide opposing particle beams of either protons at an energy of 7 TeV per particle, or lead nuclei at an energy of 574 TeV per nucleus. The LHC lies in a tunnel 27 kilometers (17 mi) in circumference, at a depth ranging from 50 to 175 meters (160 to 570 ft) underground. The 3.8-metre wide concrete-lined tunnel, constructed between 1983 and 1988, was formerly used to house the Large Electron-Positron Collider. It crosses the border between Switzerland and France at four points, with most of it in France. Surface buildings hold ancillary equipment such as compressors, control electronics and refrigeration plants.

The Large Hadron Collider was built by the European Organization for Nuclear Research (CERN) with the intention of testing various predictions of high-energy physics, including the existence of the large family of new particles predicted by supersymmetry (a symmetry that relates elementary particles of one spin to other

particles that differ by half a unit of spin). It is funded by and built in collaboration with over 10,000 scientists and engineers from over 100 countries as well as hundreds of universities and labs. With a 9 billion dollar budget, the LHC is the most expensive scientific experiment in human history.

On September 10, 2008, the proton beams were successfully circulated in the main ring of the LHC for the first time. On September 19, 2008, the operations were halted due to a serious fault between two superconducting bending magnets. On November 20, 2009, after repairing the resulting damage and installing additional safety features, the proton beams were successfully circulated again.

On November 23, 2009, the first proton-proton collisions were recorded, at the injection energy of 450 GeV per particle. On December 18, 2009, the LHC was shut down after its initial commissioning run, which achieved proton collision energies of 2.36 TeV, with multiple bunches of protons circulating for several hours and data from over one million proton-proton collisions. Then the LHC was down until February 2010 to carry out improvements in magnet protection with the aim of permitting research at 3.5 TeV per beam during the 2010 operational period.

Physicists hope that the LHC will help answer the most fundamental questions in physics concerning the basic laws governing the interactions and forces among the elementary objects, the deep structure of space and time, especially regarding the intersection of quantum mechanics and general relativity, where current theories and knowledge are unclear or break down altogether.

However, after some years of running, any particle physics experiment typically begins to suffer from diminishing returns: each additional year of operation discovers less than the year before. The way around the diminishing returns is to upgrade the experiment, either in energy or in luminosity. A luminosity upgrade of the LHC, called the Super LHC, has been proposed to be made after ten years of LHC operation.

The optimal path for the LHC luminosity upgrade includes an increase in the beam current (the number of protons in the beams) and the modification of the two high-luminosity interaction regions with general purpose detectors. To achieve these increases, the energy of the beams at the point that they are injected into the LHC should also be increased to 1 TeV. This will require an upgrade of the full pre-injector system for further optimization of the experiments.

1. Answer the following questions:
1) What is the LHC?
2) Name the predecessor of the LHC.
3) How would you explain the term of supersymmetry?
4) Prove the global scale of the LHC in facts.
5) When did the LHC start operating?
6) What was the reason for its first halt?
7) What was the date of November 23, 2009?
8) State the approximate number of proton-proton collisions.

9) What is the main sphere of interest of all the physicists with regard to the LHC?
10) How can the scientists upgrade the experiment? Why does it need upgrading?
11) What are the optimums for the LHC luminosity upgrade?

2. Use the correct words from the text:
1) On November …, 2009, after repairing the resulting damage and installing additional … …, the … … were successfully circulated again.
2) The LHC lies in a tunnel … miles in …, at a depth ranging from 160 to 570 feet underground.
3) The LHC is funded by and built in … with over 10,000 scientists and … from over … countries.
4) The way around the … returns is to upgrade the experiment, either in … or in ….
5) … is a symmetry that relates elementary … of one spin to other … that differ by half a unit of spin.
6) The … … has been proposed to be made after … years of LHC ….

3. True or false?
1) The Large Hadron Collider was built by the group of researchers from Switzerland.
2) On November 20, 2009, the proton beams were successfully circulated again.
3) The LHC crosses the border between Switzerland and France at two points.
4) Scientists hope that the LHC will help answer the most fundamental questions in physics.
5) The budget of the LHC project makes 9 million dollars.
6) The optimal path for the LHC luminosity upgrade includes an increase in the beam current.
7) The Large Electron-Positron Collider will replace the LHC in the nearest future.
8) On September 19, 2008, the operations were halted due to a serious fault between two superconducting bending magnets.
9) Surface buildings of the LHC hold a number of experimental laboratories.

4. Match words with their meanings:

1) symmetry	a) the outside of any object
2) surface	b) physical characteristic of giving out light
3) upgrade	c) numbers of small, similar objects
4) detector	d) device for speeding-up particles or nuclei
5) luminosity	e) raise to a higher level
6) bunch	f) something that makes an object imperfect
7) accelerator	g) quality of balance between parts
8) fault	h) device for catching any signals

5. Translate from Russian into English:

1) Большой адронный коллайдер – это ускоритель заряженных частиц на встречных пучках, предназначенный для разгона протонов и ионов свинца. 2) Учёные назвали коллайдер большим в первую очередь из-за его размеров, и только затем из-за того, что он является крупнейшей экспериментальной установкой в мире. 3) Если исследователям удастся подтвердить существование суперсимметрии, они также смогут доказать истинность ряда физических теорий. 4) В ускорителе предполагается сталкивать протоны с суммарной энергией 14 ТэВ (тераэлектронвольт), и, таким образом, БАК будет самым высокоэнергичным ускорителем элементарных частиц в мире. 5) Инженеры решили, что БАК будет расположен в том же туннеле, который прежде занимал большой электрон-позитронный коллайдер. 6) Период с 10 по 19 сентября 2008 года включает в себя официальный запуск большого адронного коллайдера, поиск и нахождение непрерывного циркулирующего пучка и прекращение работ в связи с неисправностью. 7) В ноябре 2009 года Европейская организация по ядерным исследованиям объявила о том, что впервые в БАК было произведено столкновение пучков протонов с суммарными энергиями 900 ГэВ. 8) Четыре основных и два вспомогательных детектора на БАК помогают учёным регистрировать места столкновения пучков и осуществлять поиск тёмной материи. 9) Скорость частиц в БАК на встречных пучках близка к скорости света в вакууме. 10) Супербольшой адронный коллайдер рассматривается как более улучшенная модификация БАК.

6. Discuss the following topics:
1) Super Large Hadron Collider
2) Construction accidents and delays of the LHC.
3) Popular culture based on the LHC.

LESSON 7.
QUANTUM CRYPTOGRAPHY: CORE AND MODERN FOCUS

Words and word combinations:

random – произвольный
bit string – битовая строка
to gain knowledge – узнавать
to eavesdrop – подслушивать
to implement – выполнять
threshold – порог
to abort – терпеть неудачу, не удаваться
encryption – кодирование
bit rate – скорость передачи битов

optical fibre – оптическое волокно
significantly – показательно
span – интервал, небольшое расстояние
entangled – сложный, спутанный
International Space Station – Международная космическая станция (МКС)
attenuation – ослабление, затухание
ballot – итоги голосования
capitol – здание центрального законодательного органа
to fund – спонсировать
resort – использование

TEXT

Quantum cryptography is the use of quantum systems to do cryptographic tasks. The most famous example here is quantum key distribution which uses quantum mechanics to guarantee secure communication. It enables two parties to produce a shared random bit string known only to them, which can be used as a key to encrypt and decrypt messages.

An important and unique property of quantum cryptography is the ability of the two communicating users to detect the presence of any third party trying to gain knowledge of the key. This results from a fundamental aspect of quantum mechanics: the process of measuring a quantum system in general disturbs the system. A third party trying to eavesdrop on the key in some way measures it, thus introducing anomalies. Transmitting information in quantum states, a communication system can be implemented which detects eavesdropping. If the level of eavesdropping is below a certain threshold, a key can be produced that is guaranteed to be secure. Otherwise, no secure key is possible and communication is aborted.

The security of quantum cryptography relies on the foundations of quantum mechanics, in contrast to traditional cryptography which relies on the computational difficulty of certain mathematical functions, and cannot provide any indication of eavesdropping or guarantee of key security.

So, quantum cryptography is only used to produce and distribute a key, not to transmit any message data. This key can then be used with any chosen encryption algorithm to encrypt and descript a message, which can be further transmitted over a standard communication channel (a wire or a radio channel).

20 years of constant development of quantum cryptography now show the very impressive results even through the modern focus of physical science. Thus, the highest bit rate system currently exchanges secure keys at 1 Mbit/s (over 20 km of optical fibre) and 10 kbit/s (over 100 km of fibre), achieved by a collaboration between the University of Cambridge and Toshiba. As of April 2009, the longest distance over which quantum key distribution has been demonstrated using optic fibre is 153.5 km, achieved by Los Alamos National Laboratory, New Mexico, US.

Significantly, this distance is long enough for almost all the spans found in today's fibre networks.

The distance record for free space quantum key distribution is 145 km between two of the Canary Islands, achieved by a European collaboration using entangled photons, in 2008. The experiments suggest transmission to satellites is possible, due to the lower atmospheric density at higher altitudes. For instance, although the minimum distance from the International Space Station to the ESA Space Debris Telescope, Tenerife Island, Spain, is about 400 km, the atmospheric thickness is about an order of magnitude less than in the European experiment, thus yielding less attenuation compared to this experiment.

Now there are only 4 companies offering commercial quantum cryptography systems, all over the world. They are located in Geneva, New York, Paris, and Acton. Quantum encryption technology provided by the Swiss company *Id Quantique* was used in the Swiss canton of Geneva to transmit ballot results to the capitol in the national election on October 21, 2007. In 2004, the world's first bank transfer using quantum cryptography was carried in Vienna, Austria. An important cheque, which needed absolute security, was transmitted from the Mayor of the city to a bank. And in October 2008, the world's first computer network protected by quantum cryptography was implemented at a scientific conference in Vienna. That project was funded by EU and it was named SECOQC (**Se**cure **Co**mmunication Based on **Q**uantum **C**ryptography). The network used 200 km of standard fibre optical cable to interconnect six locations across Vienna and the town of St Poelten 70 km to the west.

Factors preventing wide adoption of quantum cryptography outside high security areas include the cost of equipment, and the lack of a demonstrated threat to existing key exchange protocols. However, with optic fibre networks already present in many countries the infrastructure is in place for a more widespread resort.

1. Answer the following questions:
1) What is quantum cryptography? Give the example of its use.
2) How can two communicating users detect the presence of any third party?
3) Describe the principle of the security of quantum cryptography.
4) What are the results of constant quantum cryptography development?
5) State the achievement of Los Alamos National Laboratory in April 2009.
6) When did the distance record for free space quantum key distribution take place, and where?
7) How many companies are able nowadays to provide commercial quantum cryptography systems?
8) What were the fields of application of quantum cryptography in Switzerland and Austria?
9) What is SECOQC?
10) What is the basic factor for a more widespread resort of quantum cryptography in the nearest future?

2. Use the correct words from the text:
1) In … 2008, the world's first … … protected by quantum cryptography was implemented at a scientific conference in ….
2) A third … trying to … on the key in some way measures it, thus introducing ….
3) Quantum … is only used to produce and distribute a …, not to transmit any … data.
4) Quantum … technology provided by the … company … … was used in the Swiss canton of Geneva.
5) Factors … wide … of quantum cryptography outside high … areas include the cost of equipment.
6) The highest … … system currently … secure keys at … Mbit/s and … kbit/s.

3. True or false?
1) The most famous example of quantum cryptography is quantum key distribution.
2) Even one year of constant development of quantum cryptography now shows the very impressive results.
3) In 2004, the world's first bank transfer using quantum cryptography was carried in Acton, Australia.
4) The minimum distance from the International Space Station to the ESA Space Debris Telescope, Spain, is about 400 km.
5) A fundamental aspect of quantum cryptography is that the process of measuring a quantum system in general disturbs the system.
6) As of June 2006, the longest distance over which quantum key distribution has been demonstrated using optic fibre is 153.5 km.
7) If the level of eavesdropping is below a certain threshold, no secure key can be produced.
8) The SECOQC project needed 200 km of standard fibre optical cable to interconnect six locations across Vienna and its suburbs.
9) Certainly, quantum cryptography is now used to produce and distribute a secure key as well as to transmit some message data.

4. Match words with their meanings:

1) cryptography	a) process of transforming information to make it unreadable to anyone except those possessing special knowledge
2) cable	b) thing done successfully, with effort and skill
3) attenuation	c) protected bundle of insulated wires for carrying electrical power or messages
4) encryption	d) relation of weight to volume
5) communication	e) practice and study of hiding information
6) achievement	f) distance measurement in the "up" direction between a reference datum and a point or object
7) density	g) gradual loss in intensity of any kind of flux through a

	medium
8. altitude	h) process of transferring information from one entity to another

5. Translate from Russian into English:
1) Ученые определяют квантовую криптографию как метод защиты коммуникаций, основанный на некоторых явлениях квантовой физики. 2) Если информация переносится с помощью объектов квантовой механики, её можно защитить с помощью квантовой криптографии. 3) Процесс отправки и приема сообщений всегда выполняется физическими средствами, например, при помощи фотонов в линиях волоконно-оптической связи. 4) В данном случае подслушивание можно рассматривать как измерение определенных параметров переносчиков информации. 5) Используя квантовые явления, ведущие физики создадут такую систему связи, которая всегда сможет обнаружить подслушивание. 6) Попытка измерения взаимосвязанных параметров в квантовой системе вносит в нее нарушения, что приводит к разрушению исходных сигналов. 7) По уровню шума в канале легитимные пользователи всегда смогут определить степень активности третьей стороны. 8) Компании, которые предлагают пользователям коммерческие системы квантовой криптографии, успешно использовали свое оборудование во многих странах Европы, в США и Австралии для обеспечения безопасности банковского перевода или защищенной передачи важных политических данных. 9) Система свободного распространения квантового ключа в космосе позволила установить рекорд дальности передачи, который составил 145 км. 10) Интерес к квантовой криптографии со стороны коммерческих организаций и военных ведомств растет, поскольку эта технология гарантирует абсолютную защиту.

6. Discuss the following topics:
1) Free space quantum cryptography.
2) Hardware solutions for quantum cryptography.
3) The future of quantum cryptography.

LESSON 8.
BLACK HOLE INFORMATION PARADOX

Words and word combinations:

black hole information paradox – исчезновение информации в чёрной дыре
to evolve – развиваться, выделять
contentious – спорный
tenet – догмат, доктрина, принцип

no hair theorem – гипотеза «у черной дыры нет волос»
Hawking radiation – излучение Хокинга (при гравитационном коллапсе)
Liouville's theorem – теорема Лиувиля
partial trace – частичный след
conjectural – гипотетический, предположительный
AdS/CFT – гипотеза о AdS/CFT-дуальности
quantum correction – квантовая поправка
remnant – остаток
unitary – единичный
time evolution – временная эволюция
perturbation – возмущение, возмущающее влияние
event horizon – горизонт событий
to concede – уступать, отказываться

TEXT

The black hole information paradox results from the combination of quantum mechanics and general relativity. It suggests that physical information could "disappear" in a black hole, allowing many physical states to evolve into precisely the same state. This is a contentious subject since it violates a commonly assumed tenet of science – that in principle complete information about a physical system at one point in time should determine its state at any other time.

In 1975, the British theoretical physicist Stephen Hawking and the Jewish physicist Jacob Bekenstein showed that black holes should slowly radiate away energy, which poses a problem. From the no hair theorem, one would expect the Hawking radiation to be completely independent of the material entering the black hole. Nevertheless, if the material entering the black hole were a pure quantum state, the transformation of that state into the mixed state of Hawking radiation would destroy information about the original quantum state. This violates Liouville's theorem and presents a physical paradox.

More precisely, if there is an entangled pure state, and one part of the entangled system is thrown into the black hole while keeping the other part outside, the result is a mixed state after the partial trace is taken over the interior of the black hole. But since everything within the interior of the black hole will hit the singularity within a fixed time, the part which is traced over partially might "disappear," never to appear again. Of course, it is not really known what goes on at singularities once quantum effects are taken into account, which is why this theory is conjectural and controversial.

Hawking was convinced, however, because of the simple elegance of the resulting equation which "unified" thermodynamics, relativity, gravity, and Hawking's own work on the Big Bang. This annoyed many physicists, notably John Preskill, who in 1997 bet Hawking and Kip Thorne that information was not lost in black holes.

There are various ideas about how the paradox is solved. Since the 1997 proposal of the AdS/CFT correspondence, the predominant belief among physicists is that information is preserved and that Hawking radiation is not precisely thermal but receives quantum corrections. Other possibilities include the information being contained in a Planckian remnant left over at the end of Hawking radiation or a modification of the laws of quantum mechanics to allow for non-unitary time evolution.

In July 2005, Stephen Hawking published a paper and announced a theory that quantum perturbations of the event horizon could allow information to escape from a black hole, which would resolve the information paradox. His argument assumes the unitarity of the AdS/CFT correspondence which implies that an AdS black hole that is dual to a thermal conformal field theory is unitary. When announcing his result, Hawking also conceded the 1997 bet, paying Preskill with a baseball encyclopedia "from which information can be retrieved at will". However, Thorne remains unconvinced of Hawking's proof and declined to contribute to the award.

1. Answer the following questions:
1) What does the black hole information paradox suggest?
2) When did Stephen Hawking and Jacob Bekenstein show that black holes should slowly radiate away energy?
3) What would one expect the Hawking radiation to be completely independent of the material entering the black hole from?
4) What is the predominant belief among physicists?
5) When did Mr. Hawking announce a theory that quantum perturbations of the event horizon could allow information to escape from a black hole?
6) What does Stephen Hawking's argument assume?
7) What does the black hole information paradox result from?
8) Why is the black hole information paradox a contentious subject?
9) What violates Liouville's theorem and presents a physical paradox?

2. Use the correct words from the text:
1) Stephen Hawking and Jacob Bekenstein showed that … … should slowly … … energy, which … a problem.
2) Hawking was convinced because of the simple … of the resulting … which "unified" …, …, …, and Hawking's own work on the … ….
3) When announcing his result, Hawking also … the 1997 …, paying Preskill with a baseball encyclopedia "from which information can … … at will."
4) Other possibilities include the information being contained in a … … left over at the end of Hawking radiation or a modification of the laws of … … to allow for … time evolution.
5) This is a … subject since it violates a commonly assumed … of science.
6) From the … … …, one would expect the Hawking radiation to be completely … of the material entering the … ….

3. True or false?

1) The black hole information paradox results from the Big Bang theory.
2) Stephen Hawking and Jacob Bekenstein showed that black holes should slowly radiate away energy in 1955.
3) The black hole information paradox is a contentious subject since it violates a commonly assumed tenet of science.
4) The unitarity of the AdS/CFT correspondence doesn't imply that an AdS black hole that is dual to a thermal conformal field theory is unitary.
5) From the no hair theorem, one would expect the Hawking radiation to be completely independent of the material entering the black hole.
6) Thorne was fully convinced of Hawking's proof and didn't decline to contribute to the award.
7) Stephen Hawking published a paper and announced a theory that quantum perturbations of the event horizon could allow information to escape from a black hole in June 2003.
8) There are various ideas about how the paradox is solved.
9) Hawking bet Kip Thorne that information was not lost in black holes in 2007.

4. Match words with their meanings:

1) contentious	a) having the quality of oneness
2) horizon	b) a region of space from which nothing, including light, can escape
3) remnant	c) accurately expressed, exact in statement
4) black hole	d) small portion remaining of a larger thing or group
5) paradox	e) opinion, belief, or principle held to be true by someone
6) unitary	f) apparent line that separates earth from sky
7) precise	g) a statement or group of statements that leads to a contradiction
8) tenet	h) argumentative, quarrelsome

5. Translate from Russian into English:

1) Исчезновение информации в чёрной дыре означает, что физическая информация может «исчезать» в черной дыре, позволяя многим физическим состояния оставаться таким же. 2) Если есть чистое перепутанное состояние, и одна часть перепутанной системы брошена в черную дыру, в то время как другая часть находится вне черной дыры, то результатом будет смешанное состояние. 3) Из теоремы «у черной дыры нет волос» можно предположить, что излучение Хокинга будет полностью независимым от материи, попадающей в черную дыру. 4) Ученые не знают точно, что происходит с сингулярностью, если брать в расчет квантовый эффект. Именно поэтому эта теория является гипотетической и спорной. 5) Это возмущало многих физиков, в особенности Джона Прескилла, который в 1997 году заключил пари с Кипом Торном и Стивеном Хокингом относительно того, что информация не теряется

в черных дырах. 6) Как только все внутри черной дыры нарушит сингулярность в фиксированный момент времени, часть, за которой наблюдают, может частично исчезнуть и никогда не появиться снова. 7) Сам Хокинг признаёт, что общий вывод об унитарности в этом случае следует из AdS/CFT-дуальности. 8) Хокинг отказался от пари, заключенного в 1997 году, презентовав сопернику книгу «Полная энциклопедия бейсбола». 9) Прескилл утверждал, что находящаяся в чистом квантовом состоянии система, которая испытывает гравитационный коллапс, приводящий к возникновению черной дыры, будет пребывать в чистом состоянии и после испарения этой дыры, в то время как Хокинг и Торн считали это мнение ошибочным. 10) Теория об исчезновении информации в черной дыре основывается на сочетании квантовой механики и общей теории относительности.

6. Discuss the following topics:
1) Thorne-Hawking-Preskill bet.
2) Black hole thermodynamics.
3) Hawking and unitarity.

TEST

Choose the correct variant:
1. Theorists all over the world predicted the existence of … forces since 2005.
a) optical
b) lateral
c) repulsive
d) magnetic
2. Dr. Tang and his colleagues combined such two sciences as … and nanophotonics.
a) nanooptics
b) nanophysics
c) nanomechanics
d) physiology
3. One of fundamental aspects of quantum mechanics is that the process of measuring a quantum system in general … the system.
a) declassifies
b) opens
c) influences
d) disturbs
4. The world's first computer network protected by quantum cryptography was implemented at a scientific conference in ….
a) Acton
b) Geneva
c) Salzburg
d) Vienna
5. The black hole information paradox suggests that physical information could "disappear" in ….
a) a black hole
b) nowhere
c) the outer space
d) an infected computer
6. There are various ideas about how the … is solved.
a) problem
b) paradox
c) mission
d) equation

7. The … may move in plane only, like billiard-balls on the surface of the table.
a) neutrons
b) ions
c) electrons
d) protons

8. The most powerful magnet in the world is made of the alloy of …, …, and ….
a) nobelium, iron, tellurium
b) neodymium, iron, boron
c) neodymium, tin, boron
d) niobium, krypton, barium

9. Physicists hope that the … will help answer the most fundamental questions in physics.
a) electronic oracle
b) Large Electron-Positron Collider
c) Large Hadron Collider
d) Supercomputer

10. Supersymmetry is a symmetry that relates elementary particles of one … to other particles that differ by half a unit of ….
a) impulse
b) phase
c) symbol
d) spin

11. Adding just a single … to a nanowire can completely change the wire's magnetic properties.
a) atom
b) molecule
c) elementary particle
d) electrode

12. The researchers obtained their results using … computer simulations based on Density Functional Theory.
a) quantum-physical
b) quantum
c) triangulation
d) quantum-chemical

13. Direct observational evidence of … has remained elusive.
a) dark energy
b) dark matter
c) ether
d) Nonsymmetric Gravitational Theory

14. NGT is a classical theory of gravitation which tries to explain the … of the flat rotation curves of galaxies.
a) observation
b) existence
c) appearance
d) emergence

15. Liquid … is believed to be essential for the formation of life.
a) gas
b) ocean
c) water
d) medium

16. Some star systems are oriented in such a way that their … cross in front of their stars, as seen from our Earthly point of view.
a) planets
b) orbits
c) solids
d) meteorites

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