致远人刊[新年第一期&寒假特刊]

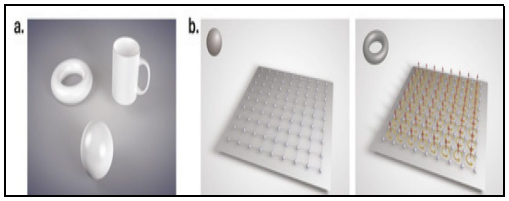
本期编辑：付景易 封晓宙 高剑飞 黄般若 姬卉 石悦琳 谢松伯（按首字拼音排序） 第 20150127 期

数学快递

Magic numbers of quantum matter revealed by cold atoms

Date: January 8, 2015

Source: Max Planck Institute of Quantum Optics



The classification of geometric objects and quantum matter. a. Topology classifies these three objects in terms of the number of handles g. The doughnut is equivalent to a mug (g=1), but differs from a ball (g=0). b. Illustration of an atomic gas trapped in a two-dimensional optical lattice: (left panel) a conventional lattice, and (right panel) a lattice subjected to an effective magnetic field. The related quantum phases are associated with different topological (Chern) numbers, schematically illustrated by the ball and the doughnut, respectively.

Topology, a branch of mathematics classifying geometric objects, has been exploited by physicists to predict and describe unusual quantum phases: the topological states of matter. These intriguing phases, generally accessible at very low temperature, exhibit unique conductivity properties which are particularly robust against external perturbations, suggesting promising technological applications. The great stability of topological states relies on a set of magic integers, the so-called Chern numbers, which remain immune to defects and deformations.

For the first time, an international team of scientists succeeded to measure the topological Chern number in a non-electronic system with high precision. The experiments were carried out with ultracold bosonic atoms controlled by lasers, in the group of Professor Immanuel Bloch (Ludwig-Maximilians-Universität Munich and Max Planck Institute of Quantum Optics, Garching) in collaboration with Nathan Goldman and Sylvain Nascimbène from the Collège de France and Nigel Cooper from Cambridge University.

Matter forms remarkable phases when it is immersed in extreme environments, such as strong magnetic fields and low temperature. Under these conditions, materials can reach unusual regimes where their electrical properties present universal and exotic behaviours, e.g. dissipationless currents and quantized electrical resistance. This physical framework sets the stage for new phases of matter, the topological states, which are described by magic (topological) integers. They are mathematical numbers used to classify geometric objects [e.g. the number of holes in a surface], and which remain immune to deformations. The outstanding fact that quantum states of matter can be associated with topological numbers guarantees the robustness of their unique electrical properties against perturbations. This suggests numerous promising technological applications, e.g. in spintronics and quantum computation, hence motivating the search for novel topological states of matter in laboratories.

Topological states were discovered in the context of the quantum Hall effect, i.e. through studies of the electrical resistance in materials subjected to strong magnetic fields. After reaching sufficiently low temperatures, the measured resistance was found to form robust plateaus when varying the magnetic field, a behaviour which was shown to be independent of the sample. Surprisingly, this universal physical property -- the quantum Hall effect celebrated by the Nobel prize in 1985 -- appeared to be rooted in topology: each resistance plateau is dictated by a topological number, the Chern number. "The beauty of this result relies in the fact that these magic mathematical numbers appear as intrinsic properties of the electrons moving in the material; it is intriguing that these abstract numbers actually lead to extraordinary observable phenomena," says theorist Nathan Goldman.

An interesting route for the search of topological phases of matter is offered by synthetic materials, which consist of ultracold atomic gases controlled by light. In these highly versatile experiments, neutral atoms are trapped in a periodic landscape created by standing waves of lasers. Cold atoms moving in these optical lattices have proven to be very well suited to mimic the dynamics of electrons propagating in real materials. However, in contrast to electrons, cold atoms are charge neutral; hence, they do not exhibit the Hall effect in the presence of a magnetic field. To overcome this limitation, new experimental techniques were developed in Munich in order to engineer effective magnetic fields for neutral atoms. In such arrangements, cold atoms behave as charged particles subjected to strong magnetic fields, offering a new platform to study the Hall effect and topological phases in a highly controllable and clean environment.

The optical-lattice setup realized in the Munich experiment has been specifically tailored so as to exhibit topological properties. Indeed, when inducing an effective magnetic field in the lattice, the atomic gas is characterized by a non-zero topological Chern number $\nu_{ch} = 1$. Nathan Goldman explains: "In this configuration, and in direct analogy with the electric Hall effect, the atomic cloud is expected to experience a characteristic transverse motion in response to an applied force (Fig. 2). Moreover, our theory predicts that this transverse drift should be directly proportional to the topological Chern number ($\nu_{ch} = 1$)." The experimentalists applied a force to their optical-lattice setup and analyzed such a displacement by taking snap-shots of the cloud. From this sequence of images, they determined an experimental value for the Chern number $\nu_{exp} = 0.99(5)$ in excellent agreement with theory. This result constitutes the first Chern-number measurement in a non-electronic system. In contrast to electronic measurements, which are based on currents flowing along the edges of the sample, the Munich Chern-number

measurement directly probes the topological nature of the bulk.

These measurements constitute an important step towards the realization and detection of topological states with ultracold atoms. Including interactions between the atoms could generate novel and exciting phases, such as the much sought after fractional Chern insulators.

来源：

http://www.sciencedaily.com/releases/2015/01/150120084541.htm

Mathematical model that learns to compensate for positioning errors can control a micromanipulation system more accurately

Date: January 20, 2015

Source: The Agency for Science, Technology and Research (A*STAR)

A mathematical model can improve the accuracy and repeatability of a positioning system by learning to anticipate tiny errors in its movements, show A*STAR researchers.

Micromanipulation systems are used to control objects' positions with exquisite precision and play a vital role in applications such as telescopes and laser communication. Most rely on feedback sensors to reach the desired position, but these sensors introduce a time lag that can reduce the accuracy in applications requiring rapid responses. Although analytic forward models (AFMs) can be used to predict when positioning errors might occur and compensate for them in advance, they must be extremely accurate and uniquely tailored to a particular micromanipulation system.

Now, Yan Wu of the A*STAR Institute for Infocomm Research in Singapore, in collaboration with colleagues from the Harbin Institute of Technology in China, has developed a system that combines both approaches. The team created a machine learning algorithm that can improve the accuracy of its analytic control model based on sensor feedback.

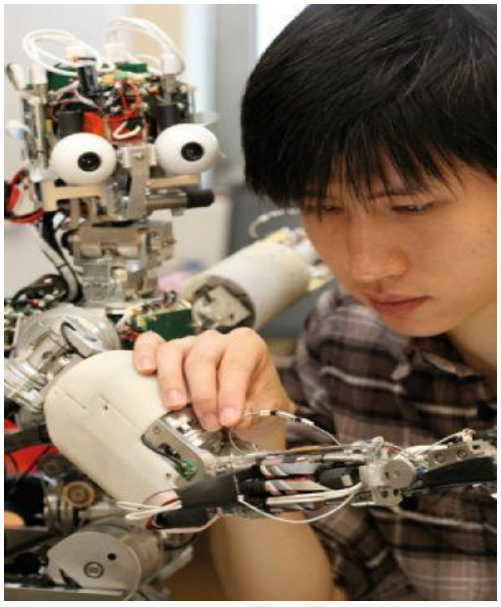
Their enhanced analytic forward model (EAFM) combines a simple AFM with a 'heteroscedastic Gaussian process (HGP) algorithm, which compensates for any residual difference between the AFM's output and the desired position.

The team built a tip-tilt micromanipulation system that uses four piezoelectric drivers to change the position of its platform. These drivers can move the platform up to 32 micrometers, and position it with an accuracy of 10 nanometers. A capacitance gauge located next to the platform can measure its position to within one nanometer (see image).

The researchers trained the HGP algorithm by running 125 random control signals through their micromanipulation system. It learned to make probabilistic predications that could compensate for errors in the AFM's output.

The team then tested the system with 30 different control signals, which were intended to move the platform by up to 28 micrometers. In every case, the EAFM system achieved smaller positioning errors than the AFM alone. And in trials of continuous movement, where the platform had to hit a series of four different points over a brief time, the EAFM outperformed the AFM in all but one of ten tests.

"All the experiments demonstrated that the AFM has errors with a very large variance (between 1 and 8 micrometers), whereas the EAFM keeps the errors at around 1 micrometer or less," says Wu. "We are now putting this micromanipulator platform into a laser communication system, while investigating methods to further reduce the steady-state errors."



Yan Wu from the A*STAR Institute of Infocomm Research in Singapore.

来源：

http://www.sciencedaily.com/releases/2015/01/150120084541.htm

Jeffrey Lagarias and Chuanming Zong to Receive 2015 AMS Conant Prize

Wednesday December 3rd 2014

Jeffrey Lagarias of the University of Michigan and Chuanming Zong of Peking University will be awarded the 2015 AMS Levi L. Conant Prize at the Joint Mathematics Meetings in January in San Antonio, Texas. They are honored for their article "Mysteries in Packing Regular Tetrahedra" (Notices of the AMS, December 2012).

Finding the most efficient packing arrangements for various objects has long occupied the attention of grocers---who want to stack their oranges in as small a space as possible---and of mathematicians. Unlike spheres, cubes can be packed with perfect efficiency, filling out space without any gaps. More than 2000 years ago, Aristotle conjectured that another example of a space-filling figure is the regular tetrahedron, a four-sided object in which each side is an equilatral triangle. It took 1800 years for people to realize that Aristotle had been wrong. Ever since then, mathematicians have been searching for the most efficient ways to pack tetrahedra. In particular, in 1900 David Hilbert listed it as a part of his 18th problem.

One milestone came in 2006, when John H. Conway and Salvatore Torquato found a packing of regular tetrahedra that fills 72 percent of space. This packing was surprisingly loose: Was there a more efficient packing out there? This question stimulated a great deal of research, including work of Lagarias' doctoral student Erica Chen, who eventually found several packings that are denser. Despite these advances, no one knows how to construct the most efficient packing or exactly how efficient it would be. All we know for certain is that no packing of tetrahedra fills all of space.

The prize-winning article by Lagarias and Zong recounts this story, discussing the first glimmers of doubt about Aristotle's conjecture and working up to the advances that have occurred in the last ten years. Their article beautifully shows the

drama and fascination of classical problems that reveal the exquisite intricacies of our world.

Part of this story was told in a New York Times article, "Packing Tetrahedrons, and Closing In on a Perfect Fit," by Kenneth Chang (January 4, 2010).

Presented annually, the Conant Prize recognizes the best expository paper published in either the Notices of the AMS or the Bulletin of the AMS in the preceding five years. The prize will be awarded at the Joint Mathematics Meetings, Sunday, January 11, 2015 at 4:25 PM, at the Henry B. Gonzalez Convention Center in San Antonio, Texas.

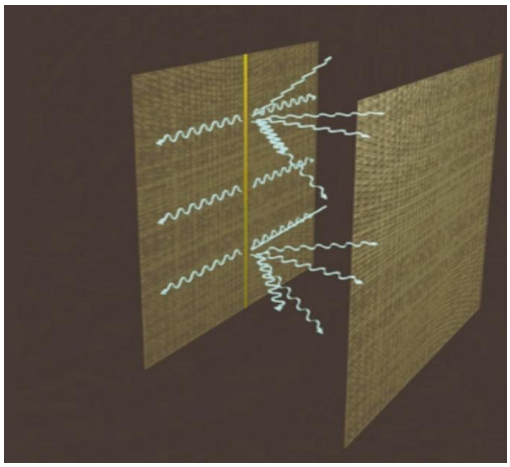
物理世界

纯理论研究脱离实验验证将危及科学

2014 年，物理学界的讨论转了令人担忧的一圈。其中，面临的难题是把基础理论应用到所观察的宇宙中。一些研究人员呼吁应就如何开展理论物理研究作出改变。他们公开争辩称，如果一项理论足够经典和具有说服力，就不必经过实证验证。这打破了几个世纪以来哲学传统把科学知识定义为“实证验证”的做法。

对此，南非开普敦大学应用数学名誉教授 George Ellis 和法国巴黎天体物理研究所及美国马里兰州巴尔迪摩约翰斯·霍普金斯大学物理学教授 Joe Silk，近日在《自然》杂志上发表了联名撰写的文章。他们表示，正如科学哲学大师卡尔·波普尔所言：理论只有经过检验才能成为科学。

弦理论



弦理论阐述了极其微小的线状“弦”（一维空间实体）与膜（更高维的扩张）如何存在于更高维的空间中。这成为所有物理学的基础。不过，更高的维度缠绕得如此紧密且如此微小，以至于几乎用未来任何粒子探测器通过碰撞获得的能量也难以观测到。

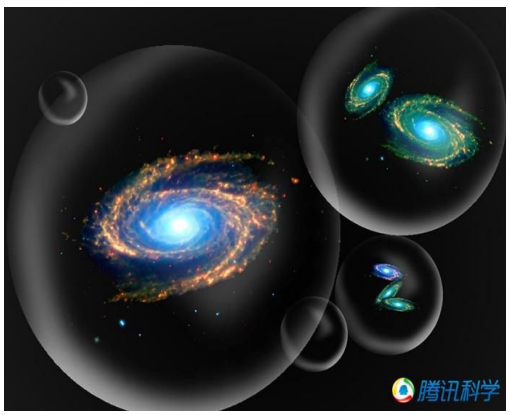
部分弦理论在理论上可以得到实验验证。比如，弦理论的核心即费米子与玻色子之间的假设对称——超对称——推测认为，每种粒子都有一个未观测到的搭档。然而，目前瑞士日内瓦欧洲粒子物理实验室欧洲核子中心（CERN）的大型强子对撞机（LHC）尚未发现这样的搭档粒子。LHC 可以限制超对称性可能存在的能量范围。

理论学家和哲学家 Richard Dawid 认为，弦理论的精确性可以通过对研究过程的哲学和概率讨论来建立。通过引用贝叶斯的分析，即用来推断一种解释与一组事实相吻合的可能性的统计学方法，Dawid 认为，概率增加的确定等同于一个理论是真实的或是可行的。但是这种概率的增加可能完全是理论上的。因为“没有人发现更好的选择办法”，而且“没有选择性的理论往往在过去是可行的”，他推理认为，弦理论应被纳入有效范畴。

Ellis 和 Silk 认为，这是在改变规则。Dawid 不相信当观测证据出现后会逐渐支持科学理论，而是认为理论发现支撑着观点，从数学逻辑推理而来的结论没有必要适用于真实世界。然而，从宇宙学稳态理论到粒子物理学的大统一理论，实验已经证明很多美丽和单纯的理论是错误的。关于这个世界的先入为主的观点可以不经过既定事实（归纳法）来推论的想法，已经被波普尔和其他 21 世纪的哲学家推翻。

科学家不知道是否存在其他可供选择的理论，或许至今尚未发现它们，或许这些前提都是错误的。如果引力—— 一种时空曲率的影响不同于控制粒子的强作用力、弱作用力与电磁力，可能就不需要四种基本作用力与粒子的总体理论。由于存在如此多的变量，弦理论的定义到今天为止甚至尚未明确：在 Ellis 和 Silk 看来，弦理论主张的可能存在一种统一理论的看法是一张不知是否可以兑现的期票。

多元宇宙论



多元宇宙理论主张，存在着数十亿个看不见的姊妹宇宙空间，在那里这些常量所有可能的值都会发生。因此，无论多么难以置信，在某个地方，存在着和我们生存的宇宙空间类似的友好宇宙空间。

一些物理学家认为，作为许多其他奇怪耦合现象的一种解释，多元宇宙论没有更复杂的对手了。比如，宇宙学常数的低值就很难被解释，该值为 120 量级，比量子场论预测的值还低 10 个量级。

2014 年早些时候，倡导多元宇宙和多元世界假说的宇宙学家 Sean Carroll 认为，波普尔的证伪标准是“迟钝的工具”。他提出了其他两个条件：科学理论应该是“确切的”“实证的”。所谓确切性，是指理论阐述的是关于现实如何发挥作用的清晰与明确的观点；所谓实证性，Carroll 同意习惯的定义，即一项理论应该通过其解释数据的能力来判断真假。

他争论称，在宇宙后院不可到达的地方可能拥有“惊人的效果”，解释了科学家可以看到的一部分，即宇宙常数为何如此小。这个理论有很多可以调整的变量，所有可能的宇宙学参数组合都可能存在于某个地方。其他理论，如幺模引力——爱因斯坦广义相对论的一个修正版本，也可以解释为什么宇宙常数并不大。

一些人发明了可被检验的多元宇宙理论：如果宇宙负空间曲率被证实，物理学家李奥纳特·苏士侃的多元宇宙版本就可以被证伪。但是这些发现对于其他一些版本的多元宇宙论而言却不能证明任何事情。基本上，多元宇宙的解释依赖于弦理论，而后者也尚未得到证实；同时也依赖于在不同的姊妹宇宙中实现不同物理现象的推测机制。Ellis 和 Silk 认为，该推测机制本身并不那么充分，更不要说实验验证了。

物理学家休·埃弗莱特提出的量子世界的多元世界理论是终极量子多元宇宙。在这个世界中，量子可能会影响宏观世界。根据埃弗莱特的观点，薛定谔的每只著名的猫——死的与活的，药死的或是通过随机放射性衰变而不在关闭的箱子中的——在其所处的世界中都是真实的。每次当你作选择的时候，甚至是稀松平常的选择向左或向右，一个选择性的量子真空宇宙都会冒出来，并适应另一个行动。

而在 Ellis 和 Silk 看来，宇宙学家应该留心数学家大卫·希尔伯特的警示：尽管无限需要完整的数学，但它并不存在于物质世界中。

是否需要验证

Ellis 和 Silk 赞同理论物理学家 Sabine Hossenfelder 的观点：后经验科学是个矛盾。一些理论如量子机制和相对论最后被证明站得住脚，是因为它们的推测经受了检验。然而，无数历史案例已经表明，由于缺乏足够数据，一些经典和具有吸引力的想法使研究人员误入歧途，从古希腊天文学家、地理学家托勒密的宇宙地心说，到英国物理学家、数学家开尔文关于原子的“涡流理论”，再到英国天文学家弗雷德·霍伊尔的永恒的稳态宇宙说皆是如此。

他们指出，过于宣扬某些理论的重要性会造成影响深远的后果——让科学方法处于危险之中。宣扬某个理论已经完美到其存在不需要任何数据和检验，会在应该如何做科学的问题上冒误导学生和公众的风险，还可能会给伪科学家大开方便之门，说他们的想法也符合类似条件。

应该怎么做呢？物理学家、哲学家和其他领域的科学家应该锤炼出能应对现代物理学范围的科学方法的新表述。Ellis 和 Silk 认为，事情可以归结为可阐明一个问题：有哪些潜在的观察或实验证据让你相信一个理论是错误的并让你放弃它？如果没有这些证据，那么它就不是一项科学的理论。

这个问题必须通过正式的哲学术语来表述。在 Ellis 和 Silk 看来，2015 年应该召开会议从而就此迈出第一步。关于可验证性辩论的双方科学家都应该参与。

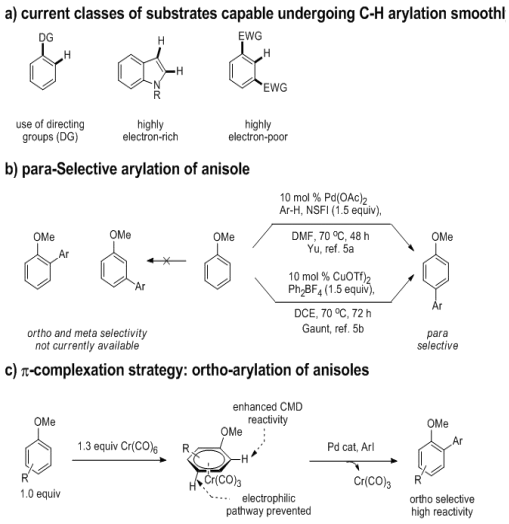
（文章来源：《自然》）

化学视角

富电子芳烃-金属π-络合物的芳基化反应

来源：

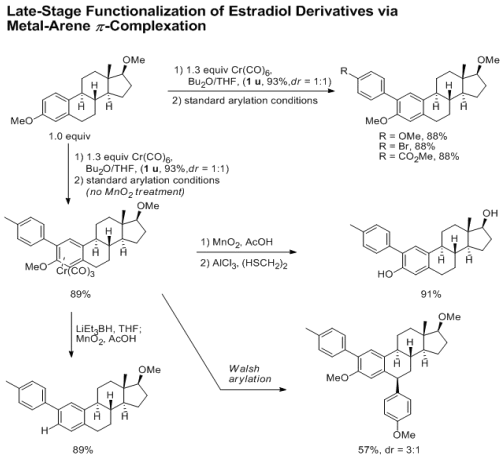
http://www.lac.dicp.ac.cn/show.php?id=280



碳氢键活化策略是构建碳碳键或碳杂键的重要工具，在医药、农药、有机材料、天然产物等领域都广泛应用。对芳烃类底物可以利用导向基团实现邻位、间位和对位的选择性碳氢键活化。然而，对没有导向基团的简单芳烃因反应活性低或区域选择性差等原因一直鲜有报道。其中，富电子的芳烃选择性的碳氢键活化更具有挑战性。最近 Larrosa 小组首次报道了富电子的苯甲醚-铬π-络合物的选择性碳氢键活化芳基化反应，以高的区域选择性和收率得到芳甲醚邻位芳基化产物。

通过条件优化，以 Pd(PPh3)4 为催化剂，以 TMP 为添加剂实现了含不同取代基芳基醚与不同的碘代芳烃反应，以较高收率得到芳基醚邻位芳基化产物，其中对 3,4-二甲基取代的芳醚可以取得最高 93%的收率。

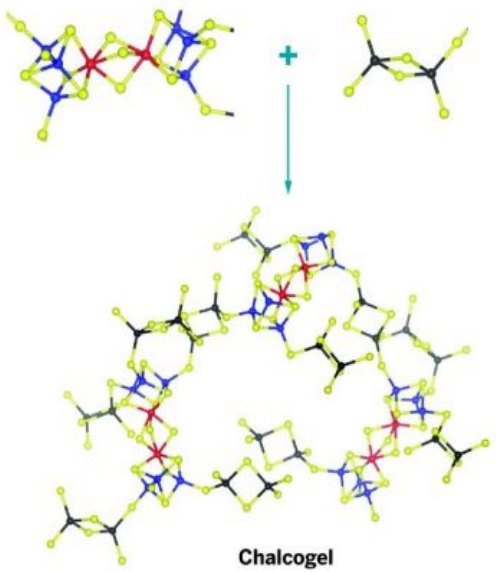
通过计算化学研究表明，该反应主要是形成了苯甲醚邻位 C-H 键弯曲到面外的过渡态，其中电子效应并不是该反应的决定因素，该反应经历协同的金属碳氢键活化去质子化过程。而且，该小组利用这一策略实现了具有生物活性的雌二醇衍生物分子芳基醚邻位芳基化应用。 (J. Am. Chem. Soc. 2014, 136, 18082.)



Photocatalyst Converts Nitrogen To Ammonia

From:

http://cen.acs.org/articles/93/i4/Photocatalyst-Converts-Nitrogen-Ammonia.html



By taking cues from two biological processes, researchers have made a catalytic material that converts nitrogen to ammonia when irradiated by white light (J. Am. Chem. Soc. 2015, DOI: 10.1021/ja512491v). The new strategy may one day help scientists achieve energy savings in various catalytic processes by capitalizing on abundant sunlight to produce valuable chemicals.

Manufacturers worldwide produce some 200 million tons of ammonia annually, mainly for use as fertilizer and for making nitrogen-containing compounds. The standard industrial process, the Haber-Bosch method, involves reacting nitrogen, which is relatively inert, with hydrogen at 400 ° C and at a pressure roughly 250 times atmospheric pressure in the presence of an iron-based catalyst. It is, of course, highly energy intensive.

Nature also converts nitrogen to ammonia, albeit far more slowly, through a process known as nitrogen fixation. The reaction, which runs under much milder conditions, occurs in microbes containing nitrogenase enzymes. These catalysts tend to include a reactive cluster of iron, molybdenum, and sulfur.

In an effort to understand nature’s energy-efficient ways, researchers previously made synthetic analogs of these clusters. They found that a few of them can catalyze ammonia production from nitrogen under strongly reducing conditions.

A team of Northwestern University chemists, including Abhishek Banerjee and Mercouri G. Kanatzidis, has now demonstrated a potentially more useful catalyst: one that can be switched on and driven by light to mediate ammonia production at room temperature and ambient pressure. Dubbed a chalcogel, the material, which mimics some aspects of nitrogen fixation and photosynthesis, is a light-absorbing, porous, amorphous solid composed of

Mo2Fe6S8 clusters linked by Sn2S6 ligands.

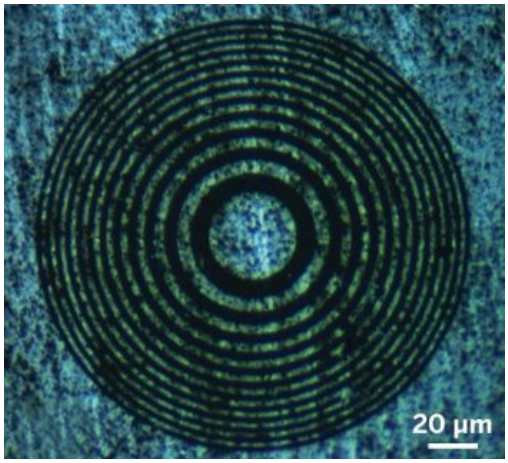
The team bubbled nitrogen through aqueous solutions containing the chalcogel, a proton source (pyridinium hydrochloride), and an electron donor (sodium ascorbate). They detected ammonia shortly after aiming a white light source at the gel and report that during irradiation the chemical’s concentration increased continuously.

Control tests show that solutions lacking the catalyst and those kept in the dark do not produce ammonia. The team acknowledges that the chalcogel evaluated in this study produces ammonia too slowly for industrial use but notes that the material remained stable with no loss of activity during a 72-hour test.

“This is extremely elegant work,” says University of Liverpool chemistry professor Matthew J. Rosseinsky. He notes that the study paves the way for further research projects to determine the catalyst’s active site structure and the role of the Sn2S6 ligands. Rosseinsky also wonders whether there is a relationship between the electronic structure of the cluster and a wavelength dependence of the catalytic activity.

Lightweight, Tunable Lenses Made From Graphene

From:
http://cen.acs.org/articles/93/web/2015/01/Lightweight-Tunable-Lenses-Made-Graphene.html



An international team of researchers has made tunable, extremely lightweight lenses using graphene (ACS Photonics 2015, DOI: 10.1021/ph500197j). The lenses act like microscopic versions of ones used in lighthouses and could help focus light onto small pixels in cell phone cameras or route laser light in computer chips that move data with photons instead of electrons.

Haider Butt of the University of Birmingham, in England; Qing Dai of the National Center for Nanoscience & Technology, in Beijing; and their colleagues designed Fresnel lenses, which are flat lenses consisting of concentric rings. The rings diffract light to create constructive interference, thus focusing the light. Lighthouses have long used Fresnel lenses to focus their beacons. The design would be key for miniaturized applications, such as in computer interconnects, because the lenses could have long focal lengths while remaining flatter, thinner, and lighter than curved lenses.

The researchers built the 50-μm-wide lenses by depositing 0.335-nm-thick layers of graphene on glass using chemical vapor deposition and then carving out the concentric circles with photolithography. The graphene rings diffract light as it passes through the lens.

The team found that the intensity of the focused light doubled when they went from five-layer to 10-layer versions of the lenses. Also, in an applied electric field, the graphene’s ability to absorb light changed, allowing the researchers to tune the intensity of the focused light.

The lenses focused 850-nm light, in the near-infrared range, but the team would like to design lenses that work at terahertz frequencies, which have promising applications in security, spectroscopy, and biological imaging.

生科发现

乳腺癌特辑

著名青年歌手姚贝娜因乳腺癌复发，于2015年1月16日下午病逝于北京大学深圳医院。在此，我们沉痛悼念姚贝娜携歌往生，天堂没有病痛，贝娜一路走好。

青年歌手姚贝娜16日因癌症去世

斯人已逝，警钟不止。关于乳腺癌的相关报道也是层出不穷。本期致远人刊，小编带你从生命科学出发，全面透析乳腺癌面面观。

乳腺癌知多少

女性乳腺是由皮肤、纤维组织、乳腺腺体和脂肪组成的，乳腺癌是发生在乳腺腺上皮组织的恶性肿瘤。乳腺癌中99%发生在女性，男性仅占1%。

乳腺并不是维持人体生命活动的重要器官，原位乳腺癌并不致命；但由于乳腺癌细胞丧失了正常细胞的特性，细胞之间连接松散，容易脱落。癌细胞一旦脱落，游离的癌细胞可以随血液或淋巴液播散全身，形成转移，危及生命。目前乳腺癌已成为威胁女性身心健康的常见肿瘤。

全球乳腺癌发病率自20世纪70年代末开始一直呈上升趋势。美国8名妇女一生中就会有1人患乳腺癌。中国不是乳腺癌的高发国家，但不宜乐观，近年我国乳腺癌发病率的增长速度却高出高发国家1～2个百分点。据国家癌症中心和卫生部疾病预防控制局2012年公布的2009年乳腺癌发病数据显示：全国肿瘤登记地区乳腺癌发病率位居女性恶性肿瘤的第1位，女性乳腺癌发病率（粗率）全国合计为42.55/10万，城市为51.91/10万，农村为23.12/10万。

相关新闻

2014年拉斯克奖揭晓

特殊贡献奖（The Special Achievement Award）今年的特殊贡献奖被授予为医学和人权做出良多贡献的华盛顿大学教授玛丽-克莱尔·金（Mary-Claire King）。

玛丽-克莱尔·金

20 世纪 60 年代，玛丽-克莱尔·金毕业于统计学专业。兴趣所致，她选修了遗传学家科特·斯特恩（Curt Stern）的遗传学课程，并被导师的提问深深吸引。后来她欣然发现解决遗传学问题的关键在于数学，因此决定进入遗传学的研究领域。在研究中，她发现了能引起遗传性乳腺癌的 BRCA1 基因位点，并在几年前发明了一种方案，可筛选所有与乳腺癌或卵巢癌发生相关的突变基因——这让乳腺癌和卵巢癌的基因检测和患病风险预测成为了可能。

安吉丽娜·朱莉切除双侧乳腺以降低乳腺癌风险

2013 年，女演员安吉丽娜·朱莉（Angelina Jolie）在被诊断出 BRCA 基因突变（该基因突变可大大增加罹患癌症的风险）后，采取了预防性的双侧乳房切除术，这成为该年度的头条新闻。

面对很多处于两难境地的女性，安吉丽娜·朱莉宣布了她的决定：双侧乳房切除术。

乳腺癌易感基因 BRCA1 和 BRCA2 介绍

乳腺癌是发达国家妇女最常见的恶性肿瘤之一，据估计 2007 年全球有 130 万乳腺癌新发患者，有超过 46 万的患者死于乳腺癌。中国近年来乳腺癌发病率高居女性恶性肿瘤的首位，并以 3%以上的速度逐年递增，保守估计全国每年有 4 万多妇女死于此病。但其发病机制目前尚不清楚，主要归纳为遗传易感性、内分泌失调、通过哺乳传染病毒颗粒等。研究者认为大约 5%的乳腺癌是由于基因突变引起的，其中肿瘤抑制基因 BRCA1 和 BRCA2 与乳腺癌发病的关系较为密切，研究证实，BRCA1 突变者 40 岁以前发生乳腺癌的概率高达 19%。BRCA1 基因在不同地区和种族中的突变不尽相同。

1995 年，科学家首次克隆乳腺癌和卵巢癌敏感基因 BRCA1 和 BRCA2。这两个基因能编码具有多重功能的蛋白，其突变表型往往具有诱发乳腺癌和卵巢癌的趋向。目前所知 BRCA1 和 BRCA2 与同源重组、DNA 损伤修复、胚胎生长、转录调控等均有关。其中，尤以两者在 DNA 损伤修复、同源重组和转录调控中的功能最为显著和重要，因为这些功能的确定将有助于探讨和阐明 BRCA1 和 BRCA2 的肿瘤抑制功能及其机理，这正是近年来癌症学家致力于研究 BRCA1 和 BRCA2 的目的所在。

BRCA1 定位于人类 17 号染色体 q21。以常染色体显性遗传方式遗传，并有很高的外显率。自 1990 年 Hall 等发现与家族性乳腺癌相关，1994 年被 Miki 等人用定位克隆技术成功克隆和分离后，国内外学者对其进行了广泛而深入的研究。BRCA1 长约 100 kb，含 24 个外显子。其基因产物是 1863 个氨基酸所构成的磷酸化蛋白质，相对分子量约 200000。

BRCA1 是调控 G/M 期关键点的调控因子，是激活 Chkl 激酶所必需的，而后者对 DNA 损伤时诱导 G/M 期阻滞起重要作用。同时，BRCA1 还控制了 Cdc25C 和 Cdc2/Cyclin B1 激酶蛋白的表达、磷酸化以及胞内定位的调节，这两种蛋白对细胞周期过程中 G/M 期的顺利进行起重要作用。BRCA1 在有丝分裂期定位于中心体，并且与中心体的重要组成成分 γ-微管蛋白相互作用。p53 也能反过来抑制 BRCA1 的表达，借此达到稳定自身的作用。野生型的 BRCA1 还能诱导凋亡并且抑制雌激素依赖性转录通路，该通路与乳腺上皮细胞增生有关,基因突变后抑制作用减弱而致病。此外野生型的 BRCA1 还能调节前列腺素的活性。

BRCA2 基因在 1994 年由 Wooster 等发现，定位于 13 号染色体 q12。全基因组 DNA 长约 70kb，其中编码区含有 10987bp，且富含 AT（约 64%），其基因序列与 BRCA1 无明显关系。BRCA2 由 27 个外显子组成，其中第 11 个外显子长约 4932bp，mRNA 长约 10.2kb，编码的 BRCA2 蛋白含 3418 个氨基酸。

正常 BRCA2 蛋白位于细胞核内,参与 DNA 的修复。在细胞周期的扩增期的表达方式和 BRCA1 相似,即在静止期的细胞中检测不到该基因的转录。在快速增殖的细胞中 BRCA2 mRNA 的表达明显增多，且表现出细胞周期依赖性，在 G0 期和 G1 早期是低的,在 G1/S 期分界时达到高峰。这些结果表明 BRCA2 对于细胞生长的调节有着重要作用。许多研究表明：BRCA2 蛋白与遗传性乳腺癌、卵巢癌及范康尼氏贫血症的发生具有密切关系，猜测其与双链 DNA 损伤修复有关，但具体作用模式与机制仍不清楚。

目前，BRCA1、BRCA2 与乳腺癌之间的密切关系已经受到越来越广泛的重视,研究也日趋深入。BRCA1、BRCA2 与家族遗传性乳腺癌的高度相关性已经毋庸置疑。通过对 BRCA1 的检测，可以反映乳腺癌的发生发展，也可筛检出乳腺癌、卵巢癌及其他相关恶性肿瘤的高危人群，利于该类疾病的早期诊断治疗。虽然 BRCA2 抑癌作用的具体机制、途径尚未明了，但是通过对 BRCA2 检测，可以早期发现乳腺癌及其他几种恶性肿瘤，如前列腺癌、卵巢癌等，并可选择合理有效的治疗方案。

研究还表明，或可通过检测上述两种基因突变，进行预防性的外科手术或化学药物预防。并且，据最新报道（Lancet 2010;376:235-244），一种新型的口服多聚 ADP 核糖聚合酶 olaparib 能诱导 BRCA 缺陷的细胞合成致死，可用于 BRCA1 或 BRCA2 突变的晚期乳腺癌女性，最常见的药物相关的不良反应事件为疲乏、恶心、呕吐和贫血。而低剂量组最常见恶心和疲乏。该研究为 BRCA 缺陷的乳腺癌的个性化治疗提供了依据。

科研进展综述

乳腺癌相关研究领域充满活力,新的研究结果不断充实我们对乳腺癌的认识,并推动观念的更新。跟踪乳腺癌诊断治疗领域的研究进展有利于确定研究方向,有助于在循证医学原则指导下不断优化乳腺癌诊断治疗体系,提高乳腺癌的诊疗水平。

乳腺癌的早期诊断(early diagnosis)

2005 年 10 月,Berry 等在 NEJM 上发表了一项研究结果,该研究应用 7 种不同的统计学模型分析了美国 1975-2000 年乳腺癌普查与辅助治疗对同时期乳腺癌死亡率的影响。研究结果显示,在参加乳腺癌普查的人口比例大幅度增长,与应用辅助性化疗和内分泌治疗方法治疗乳腺癌的比例明显增加的大前提下,乳腺癌死亡率的降低与普查和辅助性治疗的综合因素相关,而无法用任何一项单一因素解释。乳腺钼靶照相、临床体检与乳腺定期自检是以往乳腺癌普查的常用方法。临床体检以发现可触及的乳腺癌为主,最高的敏感性数据源于加拿大国家乳腺普查研究Ⅱ,为 63%,一般为 48%~60%,但是可发现部分乳腺钼靶普查出的间期癌。

乳腺癌的外科治疗

乳腺癌的治疗理念已经开始从应用“可耐受的最大量治疗”向应用“有效的最小量治疗”转变,外科治疗方式的变迁是这一转变的最好写照。

在循证医学高等级证据的支持下,“保留乳房治疗”已经成为目前乳腺癌外科治疗的主流方式。“钼靶照相除外临床多中心(非局限性)

病灶”,“切缘无癌的病灶完全切除”和“术后全乳放射治疗”3 大要素构成了“保留乳房治疗”的安全保障体系。前哨淋巴结活检技术是当代乳腺癌治疗的另一标志。虽然尚没有循证医学Ⅰ级证据支持前哨淋巴结阴性病例避免腋窝淋巴结清扫的安全性,但是越来越多的单中心研究结果(Ⅱ级证据)支持了此项技术在一些乳腺癌治疗中心的应用。

复发转移的风险评估

复发转移的风险评估对指导辅助性系统性治疗有重要意义。2005 年初,在瑞士 St. Gallen 举行的第 9 届“早期乳腺癌治疗国际研讨会”上,专家们对 St. Gallen 2003 乳腺癌辅助治疗指南中的风险因素进行了调整,“激素受体表达”作为治疗选择因素而不再作为风险评价因素,新增“瘤周脉管癌栓与 Her-2 过度表达”作为风险评价因素。

乳腺癌系统性辅助治疗

2005 年最突出的进展可能是曲妥珠单抗用于在 Her-2 过度表达乳腺癌的辅助治疗。第 28 届圣安东尼奥乳腺癌会议上,Soon 报告的 NSABP-31(AC→T 对 AC→TH)试验资料的回顾性分析结果显示,Her-2 与 cMyc 同时过表达病例在无复发生存方面从 AC→TH 治疗中获益最大。在辅助内分泌治疗方面,BIG 1-98 的初步结果再次表明,与传统的他莫昔芬相比,芳香化酶抑制剂在无病生存方面具有优势。而 2005 年圣安东尼奥乳腺癌会议上报告的 ITA、ARNO95 与 ABCSG 8 试验数据的荟萃分析结果表明,他莫昔芬治疗 2~3 年后换用阿那曲唑不但改善了无病生存率(HR=0.59,P<0 hr="0.71,P=0.038)。该研究结果提示,完成 5 年他莫昔芬治疗并经历了一段无治疗状态的激素受体阳性乳腺癌患者,可以通过来曲唑的继续治疗获得生存状态的进一步改善。

展望

乳腺癌的治疗模式正从“可耐受的最大量治疗”向 “有效的最小量治疗”过渡。界定“有效的最小量治疗”将是今后一段时间内的研究重点。由于“普查发现的乳腺癌比例”逐步上升,“早期”乳腺癌的治疗也将是研究的热点。“系统性辅助治疗中普遍存在过度治疗”的共识也将推动“治疗必要性”的预后指标与“治疗有效性”的预测指标的深入研究。

结语

读者可见,近十年来乳腺癌的诊治已有了巨大的突破。我们有理由相信,随着科技发展,乳腺癌等诸多顽症将不再带来死亡的气息。人类能真正享受生命科学的研究结晶,过上更高质量的生活。

以上资料来源: http://so.bbioo.com/ 、http://www.biodiscover.com/、凤凰网、搜狐网、果壳网

计科资讯

This Computer Knows When to Hold 'em, Knows When to Fold 'em

January 8, 2015

Researchers have developed a poker-playing computer program that can defeat even the best human players.

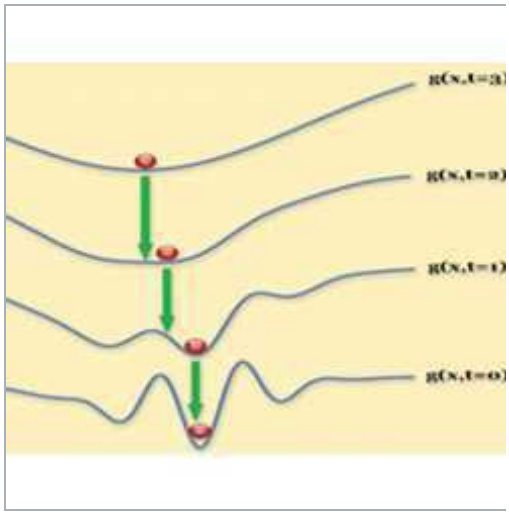
Card sharks, beware. A new program cannot be beaten at a variety of poker called heads-up limit Texas Hold ’ em—at least in a human lifetime — a team of computer scientists reports. Researchers had previously developed unbeatable algorithms for other games such as checkers, but the new work marks the first time scientists have found such an algorithm for—or "solved"—a complex game in which some information about the state of the game (i.e., the cards in his opponent ’ s hand) remains hidden from the player. The program has yielded insights that could help players improve their game, and the general approach may have real-world usefulness in security and health care applications.

Because of the hidden information and the luck of the draw, the program won't necessarily win every hand, explains computer scientist Michael Bowling of the University of Alberta in Edmonton, Canada, who led the study. But on average the program is so good that a human would have no chance of ever edging ahead of it, even if the two played 60 million hands. So “for all purposes that anyone would ever care about, we’ ve solved the game,” Bowling says.

From Science Magazine

Optimizing Optimization Algorithms

January 23, 2015



This sequence of graphs illustrates the application of the researchers' technique to a real-world computer vision problem. The solution to each successive problem (red balls) is used to initialize (green arrows) the search for a solution to the next.

Optimization algorithms are used to determine the minimum values of mathematical functions, and are widely used for such purposes as evaluating design tradeoffs and control systems as well as finding patterns in data. At a conference in mid-January, Massachusetts Institute of Technology's Hossein Mobahi and John Fisher presented a way to generate a sequence of simplified functions that ensure the best approximation the method can offer.

Their approach attempts to identify a convex approximation of an optimization problem through the use of Gaussian smoothing, which converts the cost function into a related function that gives a weighted average of all the surrounding values. The technique also minimizes abrupt dips or ascents in the cost function's graph. The weights assigned the surrounding values are determined by a Gaussian function, or normal distribution, also known as the bell curve. The width of a Gaussian function is determined by a single parameter.

Mobahi and Fisher initially use a very wide Gaussian, which, under certain conditions, yields a convex function, and gradually contract the width of the Gaussian to generate a series of intermediary problems. By the time the width of the distribution

becomes zero, the original cost function is recovered because every value is the average of itself.

From MIT News

Artificial-Intelligence Experts to Explore Turing Test Triathlon

January 20, 2015

At the upcoming convention of the Association for the Advancement of Artificial Intelligence, attendees will meet to work out an alternative to the Turing Test.

It was billed as an epochal event in humanity ’ s history: For the first time a computer had proved itself to be as smart as a person.And befitting the occasion, the June story generated headlines all around the world. In reality, it was all a cheesy publicity stunt orchestrated by an artificial-intelligence buff in England. But there was an upside. Many of the world ’ s best-known AI programmers were so annoyed by the massive coverage, which they deemed entirely misguided, that they banded together. They intend to make sure the world is never fooled by false AI achievement again. The result is a daylong workshop, "Beyond the Turing Test," where attendees aim to work out an alternative to the current test. The workshop will be held this coming Sunday in Austin at the annual convention of the Association for the Advancement of Artificial Intelligence.

From IEEE Spectrum

Vision System for Household Robots

January 14, 2015

Researchers at the Massachusetts Institute of Technology say a new algorithm allows robots to assemble different perspectives of the same scene to recognize more objects.

Massachusetts Institute of Technology (MIT) researchers say they have developed an algorithm that can aggregate different perspectives and recognize four times as many objects as one that uses a single perspective while reducing the number of misidentifications, and that works 10 times faster than conventional algorithms.

"If you just took the output of looking at it from one viewpoint, there's a lot of stuff that might be missing, or it might be the angle of illumination or something blocking the object that causes a systematic error in the detector," says graduate student Lawson Wong, a researcher in MIT's Computer Science and Artificial Intelligence Laboratory.

The researchers tested the algorithm using scenarios in which they had 20 to 30 different images of household objects clustered together on a table. In several of the scenarios, the clusters included multiple instances of the same object, closely packed together, which makes the task of matching different perspectives more difficult. The algorithm does not discard any of the hypotheses it generates across successive images, and instead samples from them at random.

Because there is significant overlap between different hypotheses, a large-enough number of samples will typically yield consensus on the correspondences between the objects in any two successive images.

From MIT News

You Will Be Able to Touch the Internet by 2035, and It Will Touch Back

January 9, 2015

Dresden University of Technology professor Gerhard Fettweis says the speed of the next generation of wireless technology could allow users to remotely manipulate something far away and have it feel as though they were interacting with something right in front of them.

Dresden University of Technology professor Gerhard Fettweis believes the next generation of wireless technology, G5, could be so fast that within 20 years it would match the speed of the human neural system, potentially enabling people to interact with distant places in the world in real time in a very lifelike fashion.

He says that through various devices, such as robots and feedback devices, people could remotely manipulate something far away and have it feel as though they were interacting with something directly in front of them. Fettweis calls this the "Tactile Internet" in a new study published in December. Fettweis sees numerous potential applications for the Tactile Internet. For example, he says it could be extremely useful in educational settings, enabling students to virtually "travel" to far away places or allow people to learn new skills such as flying or surfing without having to leave their homes. It also could create lifelike long-distance conversations. One area of particular promise is medicine. Combined with tele-robotics, the Tactile Internet could enable a doctor half way across the world to interact with a patient as though they were in an exam room together.

Fettweis says the first glimmers of the faster networks that could make the Tactile Internet possible are at least 10 years away.

From Quartz