

0005 用激光来核聚变点火

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1. 激光 核聚变点火

Un peu d'histoire

主 The idea of harnessing(v.)控制，利用（以产生能量等）the process that powers(v.) the sun 谓 goes back almost as far as the discovery, in the 1920s and 1930s, of what that process is —namely the fusion 融合, 核聚变 of protons, the nuclei 核心, 原子核 of hydrogen atoms, to form(v.) helium 氦 nuclei (4He), also known as alpha particles. This reaction yields(v.) 出产（作物）；产生（收益、效益等）；提供 something less than the sum of its parts, for an alpha particle is lighter than four free protons. But the missing mass has not disappeared; it has merely been transformed. As per 按照，依据；如同 Einstein's equation, $E = mc^2$, it has been converted into energy, in the form of heat.

Example 1. 标题

harness

/ˈhɑːrnɪs/ (v.)~ sth (to sth)to put a harness on a horse or other animal; to attach a horse or other animal to sth with a harness 给（马等）上挽具；用挽具把...套到...上 /控制，利用（以产生能量等）

nuclei

/ˈnuːkliə/ n.核心，核子；原子核（nucleus 的复数形式）

helium

/ˈhiːliəm/ 氦

yield

/jiːld/ (v.)出产（作物）；产生（收益、效益等）；提供

- trees that no longer yield(v.) fruit 不再结果实的树

掌控“为太阳提供能量的过程”这种力量, 这个想法可以追溯到 1920 年代和 30 年代, 那时发现了其原理是什么——即质子的聚变, 即氢原子核转变成了氦核 (4He), 也称为阿尔法粒子。这个反应产生出的物质, 质量小于原先各部分的总和, 因为一个 alpha 粒子比四个自由质子轻。但是丢失的质量并没有消失; 它只是被转变了。根据爱因斯坦方程式 $E = mc^2$, 它已经以热的形式, 转化成了能量。

This sounded(v.) technologically promising. But it was soon apparent 显而易见 that 主 doing it the way the sun does 系 is a non-starter(n.).

Example 2. 标题

non-starter

(n.)(informal) a thing or a person that has no chance of success 无望取得成功的人（或事）/虽参赛但未上场跑的马

这在技术上听起来很有前景。但很快人们就发现，要想做到像太阳那样的过程，是不可能的。

主 Persuading nuclei to fuse(v.) (使)融合 谓 requires heat, pressure or both. The pressure reduces(v.) the space between the nuclei, encouraging 促进; 助长; 刺激 them to meet. The heat keeps them travelling fast enough that when they do meet, they can overcome(v.) their mutual 相互的; 彼此的 electrostatic 静电的 repulsion 强烈的反感, 排斥力; 斥力 known as the Coulomb barrier 屏障; 障碍物, and thus allow a phenomenon called the strong nuclear force 强核力, which works(v.) only at short range 范围, to take over (用武力)接管,取代. The strong force holds(v.) protons and neutrons 中子 together to form(v.) nuclei, so once the Coulomb barrier is breached 违反; 违背,在...上打开缺口, a new and larger nucleus quickly forms(v.).

Example 3. 标题

electrostatic

/ɪˌlektroʊ-ˈstætɪk/ (physics 物) used to talk about electric charges that are not moving, rather than electric currents 静电的

1. repulsion /rɪˈpʌlʃ(ə)n/ (n.) a feeling of very strong dislike of sth that you find extremely unpleasant 嫌恶感; 强烈的反感; 憎恶
(physics 物) the force by which objects tend to push each other away 排斥力; 斥力

Coulomb barrier

/ˈkuːləːmˈkuːləʊm/, /ˈbæriər/ 库仑障壁, 库仑势垒

range

PHRASE If you see or hit something at close range or from close range, you are very close to it when you see it or hit it. If you do something at a range of half a mile, for example, you are half a mile away from it when you do it.
近距离内

让原子核发生聚变, 需要热量、压力, 或两者兼而有之。压力缩小了原子核之间的空间, 促使它们相遇。热量使它们移动得足够快, 以至于当它们相遇时, 它们可以克服相互间的静电斥力, 也就是所谓的库仑势垒, 从而允许一种只在近距离内起作用的强核力现象发生。强作用力将质子和中子结合在一起形成原子核, 因此一旦库仑势垒被突破, 一个新的更大的原子核就会迅速形成。

主 The temperature at which solar fusion occurs(v.), though high (15.5m°C), 系 is well within engineers' reach. Experimental 实验性的; 试验性的 reactors 核反应堆 can manage(v.) 100m°C and there are hopes to go higher still. But the pressure (250bn atmospheres) eludes(v.) (尤指机敏地) 避开, 逃避, 躲避 them. Moreover, solar fusion's raw material is recalcitrant(a.) 桀骜不驯的; 难以控制的. The first step on the journey to helium 氦—fusing(v.) two individual protons together to form(v.) a heavy isotope 同位素 of hydrogen called(v.) deuterium 氘 (a proton and a neutron)—is reckoned(v.)想; 认为 to take, on average, 9bn years.

Example 4. 标题

elude

/ɪluːd/ (v.) to manage to avoid or escape from sb/sth, especially in a clever way (尤指机敏地) 避开, 逃避, 躲避 / 使达不到; 使不记得; 使不理解
→ e-, 向外. -lud, 玩耍, 欺骗, 词源同allude, collude. 引申义逃走, 逃避。

- He was extremely tired but sleep eluded(v.) him. 他累极了, 却睡不着。

recalcitrant

adj. /rɪ'kæl-sɪ-trənt/ (formal) unwilling to obey rules or follow instructions; difficult to control 不守规章的；不服从指挥的；桀骜不驯的；难以控制的

→ re-, 向后，往回，-calc, 脚跟，踢，词源同 calcaneus, decal, inculcate. 引申词义难以控制的。

isotope

a. /'aɪsə-təʊp/ 同位素

→ iso-, 等，同，-top, 位置，地方，词源同 topic, utopia. 即等位置的，引申词义同位素。

deuterium

/dju:'tɪ-rɪəm, du:'tɪrɪəm/ 氘，重氢（氢的同位素）

→ deuter-, 二，词源同 two. 因这种物理元素其质量为氢的两倍而得名。比较 tritium.

发生太阳聚变的温度虽然很高(15.5m°C)，但在工程师的能力范围内。实验反应堆的温度可以控制在1亿摄氏度，而且还有希望继续升高。但压力(2500亿大气压)却与他们无缘。此外，太阳核聚变的原料是难以驾驭的。到达氦的第一步——将两个单独的质子融合在一起，形成氢的重同位素氘(一个质子和一个中子)——据估计平均需要90亿年时间。

What engineers propose 系 is thus a simulacrum(n.) 假象；模拟物；幻影 of the solar reaction. 主 The usual approach — that taken by General Fusion, Tokamak Energy, Commonwealth Fusion and First Light, as well as government projects like JET and ITER — 系 is to start with deuterium 氘 and fuse(v.) it with a yet (强调程度的增加) 更-heavy (and radioactive(a.) 放射性的；有辐射的) form of hydrogen called(v.) tritium 氚 (a proton and two neutrons) to form(v.) 4He and a neutron. (Fusing(v.) deuterium nuclei 氘核 directly, though sometimes done(v.) on test runs, is only a thousandth as efficient.)

Example 5. 标题

simulacrum

/,sɪ-mju-'leɪ-kɹəm/ (n.) (formal) something that looks like sb/sth else or that is made to look like sb/sth else 假象；模拟物；幻影

tritium

/tri-'tiəm/ 氚（氢的同位素）

→ 来自希腊语 tritos, 第三，词源同 three, third. -ium, 化学元素后缀。比较 deuterium.

因此，工程师们提出的是一个太阳反应的模拟。通用核聚变公司、托卡马克能源公司、联邦核聚变公司和第一光公司，以及JET和iter等政府项目，采用的通常方法，是从氘开始，将其与一种更重(具有放射性)的氢——氚(一个质子和两个中子)融合，形成4He和一个中子。(直接聚变氘核，虽然有时在试验中进行，但效率只有千分之一。)

In December 2022 /the NIF caused 使发生；造成；引起 a flutter 振动, 抖动, 紧张兴奋 by announcing it had reached ignition 点火；点燃. But the energy released 系 was less than 1% of that expended 花费, 耗费, meaning it was nowhere 无处；哪里都不 near another sine qua non 必要条件的 of commercial fusion, $Q > 1$. Q is the ratio of the energy coming out of a machine to that going in. Different versions of Q have different definitions of “out” and “in”. But 主 the one most pertinent(a.) 恰当的；相宜的 to commerce 贸易；商业 系 is “plug to plug” — the electricity drawn grid (输电线路、天然气管道等的) 系统网络；电网 to run(v.) the whole caboodle /versus(v.) the energy delivered 递送；传送到 back the grid. Focused(a.) 注意力集中的；目标明确的, Marvel and Xcimer hope(v.) to match that definition of $Q > 1$.

Example 6. 标题

sine qua non

/sɪ-neɪ kwɑ: 'nəʊn/ ~ (of/for sth) (from Latin informal) something that is essential before you can achieve sth else 必要条件

→ From Latin sine qua non (“without which [cause] not”).

pertinent

/pɜːrt(ə)-nənt/ (a.) ~ (to sth) (formal) appropriate to a particular situation 有关的；恰当的；相宜的
→ per-贯穿 + -tin-握,持有 + -ent形容词词尾

- Please keep your comments pertinent(a.) to the topic under discussion. 请勿发表与讨论主题无关的言论。

caboodle

/kəˈbuːdl/ THE WHOLE (KIT AND) CA'BOODLE (informal) everything 全部；全体
→ 来自kit和bundle的合成词。

- I had new clothes, a new hairstyle —the whole caboodle. 我身着新衣服，头理新发型——上下一身新。

2022年12月，NIF宣布它已达到点火状态，引起了轰动。但释放的能量不到消耗能量的1%，这意味着它离商业聚变的另一个必要条件 $Q > 1$ 还很远。 Q 是机器输出的能量与输入的能量之比。不同版本的 Q 对“输出”和“输入”有不同的定义。但与商业最相关的是“即插即用”——即，从电网获取能量以运行整个聚变反应堆所需的电力，与将产生的能量输回电网的能量之间的比率。Marvel和Xcimer专注于满足 $Q > 1$ 的定义。

证明“可控核聚变”可行性的第一步，就是“ $Q > 1$ ”，即输出的能量，大于维持反应所需输入的能量，核聚变反应可以依靠自身产生的能量维持。这一临界状态被称作收支平衡，也叫“点火”。

2. <pure> 激光核聚变点火

Un peu d'histoire

The idea of harnessing the process that powers the sun goes back almost as far as the discovery, in the 1920s and 1930s, of what that process is — namely the fusion of protons, the nuclei of hydrogen atoms, to form helium nuclei (4He), also known as alpha particles. This reaction yields something less than the sum of its parts, for an alpha particle is lighter than four free protons. But the missing mass has not disappeared; it has merely been transformed. As per Einstein's equation, $E = mc^2$, it has been converted into energy, in the form of heat.

This sounded technologically promising. But it was soon apparent that doing it the way the sun does is a non-starter.

Persuading nuclei to fuse requires heat, pressure or both. The pressure reduces the space between the nuclei, encouraging them to meet. The heat keeps them travelling fast enough that when they do meet, they can overcome their mutual electrostatic repulsion, known as the Coulomb barrier, and thus allow a phenomenon called the strong nuclear force, which works [only at short range], to take over. The strong force holds protons and neutrons together to form nuclei, so once the Coulomb barrier is breached, a new and larger nucleus quickly forms.

The temperature at which solar fusion occurs, though high ($15.5\text{m}^\circ\text{C}$), is well within engineers' reach. Experimental reactors can manage $100\text{m}^\circ\text{C}$ and there are hopes to go higher still. But the pressure (250bn atmospheres) eludes them. Moreover, solar fusion's raw material is recalcitrant. The first step on the journey to helium — fusing two individual protons together to form a heavy isotope of hydrogen called deuterium (a proton and a neutron) — is reckoned to take, on average, 9bn years.

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