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液晶中的魔法

制造显示屏的神奇材料拥有创造未来技术的惊人潜力。

物理学中最吸引人的领域或许是宇宙学和那些寻找新基本定律的研究。但除此之外，还有一个前沿领域也是非常有意思的，那就是寻求魔法。当然，我指的不是骗人的小把戏，而是科幻作家亚瑟•C•克拉克（Arthur C. Clarke）所诠释的那种魔法--他有个著名的定律：“任何足够先进的科技，皆与魔法无异。”

可是现代魔法还有另外一个分支，它的源头不像量子力学那样显赫，至今没有受到足够的重视，还有非常巨大的潜力尚未发挥出来。你可以从肥皂盒里黏糊糊的残渍中隐约察觉到它的蛛丝马迹。基础科学课常常宣称物质有三态：固态、液态和气态，然而自然界中的物态远比这丰富。这种黏性物质就属于三态之外的另一种物态：液晶。

液晶是一种既能像液体一样流动，又能像晶体一样与光发生相互作用的独特物态。它们通常由较长的有机分子构成。液晶的奇妙之处在于，一方面这些分子定向排列成某种规则的图案，而另一方面它们的中心却可以自由移动。这些方向固定的分子就像一个个小的电磁波接收天线，可以吸收光，并将其转换成另外的形式。

由于液晶兼有晶体改变光的能力与液体的流动性，它们可以用于制作超柔韧、对颜色敏感的棱镜和偏振片。这使得它们在显示器制造方面极为有用。实际上，液晶是绝大多数现代计算机显示屏的核心材料。

液晶的数学理论融合了晶体复杂的对称性与流体丰富的动力学，并进一步分析了这些因素对液晶的光学特性有怎样的影响。1991 年，法国物理学家皮埃尔-吉勒•德热纳（Pierre-Gilles de Gennes）因其对液晶理论的贡献荣获诺贝尔物理学奖。

然而我们对液晶的理解还远不止于此，更神奇的是，液晶还是生命的核心。有一种特殊的二维液晶，它卷曲形成闭合球面，组成了细胞表面以及细胞内不同功能单元之间的薄膜。这些液晶能选择性地让各类不同物质通过，从而让细胞可以进食、消化、排泄与呼吸。它们还会生长、发芽和分裂，而这些活动正是生物发育与繁殖的根本基础。

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在这方面，人类的工程师还远不及大自然。我们的机器不会复制、生长和自我修复，在调控与环境的互动时，也远达不到生物那般的精妙复杂。人类发展液晶技术的主要瓶颈是：尽管我们有描述液晶的出色方程，却并不擅长利用它来指导创新设计。

这个问题可能太复杂了，以至于超越了我们大脑本身的能力。而边做边学（或更准确地说，边模拟边学）的计算机程序则很可能胜过我们人类的逻辑推导，帮我们获得更多的成功设计。技术就是这样进步的：今天的魔法会孕育出明天的魔法。

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Finding the Magic in Liquid Crystals

The uncanny material in your TV display may hold astonishing potential for creating future technologies.

The most glamorous fields in physics are probably cosmology and the search for new fundamental laws. While those subjects are glorious, there's also another frontier to relish: the pursuit of magic. Of course, here I don't mean trickery but magic in the spirit of the science-fiction writer Arthur C. Clarke's famous law: "Any sufficiently advanced technology is indistinguishable from magic."

But there's another branch of modern magic, underappreciated and still vastly underdeveloped, that has humbler origins. You can see a hint of it in the gooey residue left behind in your soap dish. Elementary science classes advertise three "states of matter"—solid, liquid and gas—but that barely scratches the surface of what's out there. That goo is something else: a liquid crystal.

Liquid crystals, which flow like liquids but interact with light like crystal, are a distinct phase of matter. They are usually made from long organic molecules. Their basic secret is that those molecules are oriented in regular patterns, while their centers can move freely. The oriented molecules act like little antennas for the electromagnetic waves we see as light. They absorb those waves and then retransmit them in altered forms.

Because liquid crystals combine light altering properties with fluidity, they can provide ultra-flexible, color-sensitive lenses and polarizers. This makes them tremendously useful for building visual displays. Indeed, liquid crystals are central players in most modern computer screens.

The mathematical theory of liquid crystals combines the intricate symmetry of crystalline patterns with the dynamical richness of liquid flows and then examines how these elements interact with light. In 1991, Pierre-Gilles de Gennes won the Nobel Prize in Physics for his contributions to that theory.

Yet when it comes to our understanding of liquid crystals, the best is yet to come. In fact, liquid crystals are central to life itself. A special kind of two-dimensional liquid crystal, closed up into sphere-like surfaces, forms the membranes that define the boundaries of cells and of functional units within cells. These crystals can selectively dissolve complex protein molecules, thus accommodating cellular eating, digestion, excretion and respiration. They can also grow, bud and fission—activities that are the soul of biological development and reproduction.

Human engineers haven't caught up to nature's skill in this medium. Our machines don't reproduce, develop, heal or regulate intercourse with their environment with anything approaching the sophistication of biology. A major bottleneck is that although we have good equations for liquid crystals, we're not yet good at using those equations to guide creative design.

This problem may be too complicated for unaided human brains. It seems likely that computer algorithms, which learn by doing (or, more accurately, by simulating), will yield more successful designs than conventional human logic. In this way, today's magic will conjure up tomorrow's.

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Winner of the Nobel Prize in Physics 2004

Director of Tsung-Dao Lee Institute