



## FOREWORD

### The Currents of Our Times

Neil deGrasse Tyson

Energy is a relatively modern concern of physics, not fully understood until well into the 19th century. The environment, too, is also a relatively modern concern. Civilization didn't care much for it until well into the 20th century.

Today, we think of energy as the driver of civilization. We fight wars over access to it. We cultivate it. We also squander it. We also implicate our use of energy as a destabilizing force on our environment. Two previously distinct branches of human interest have now merged into a single realm.

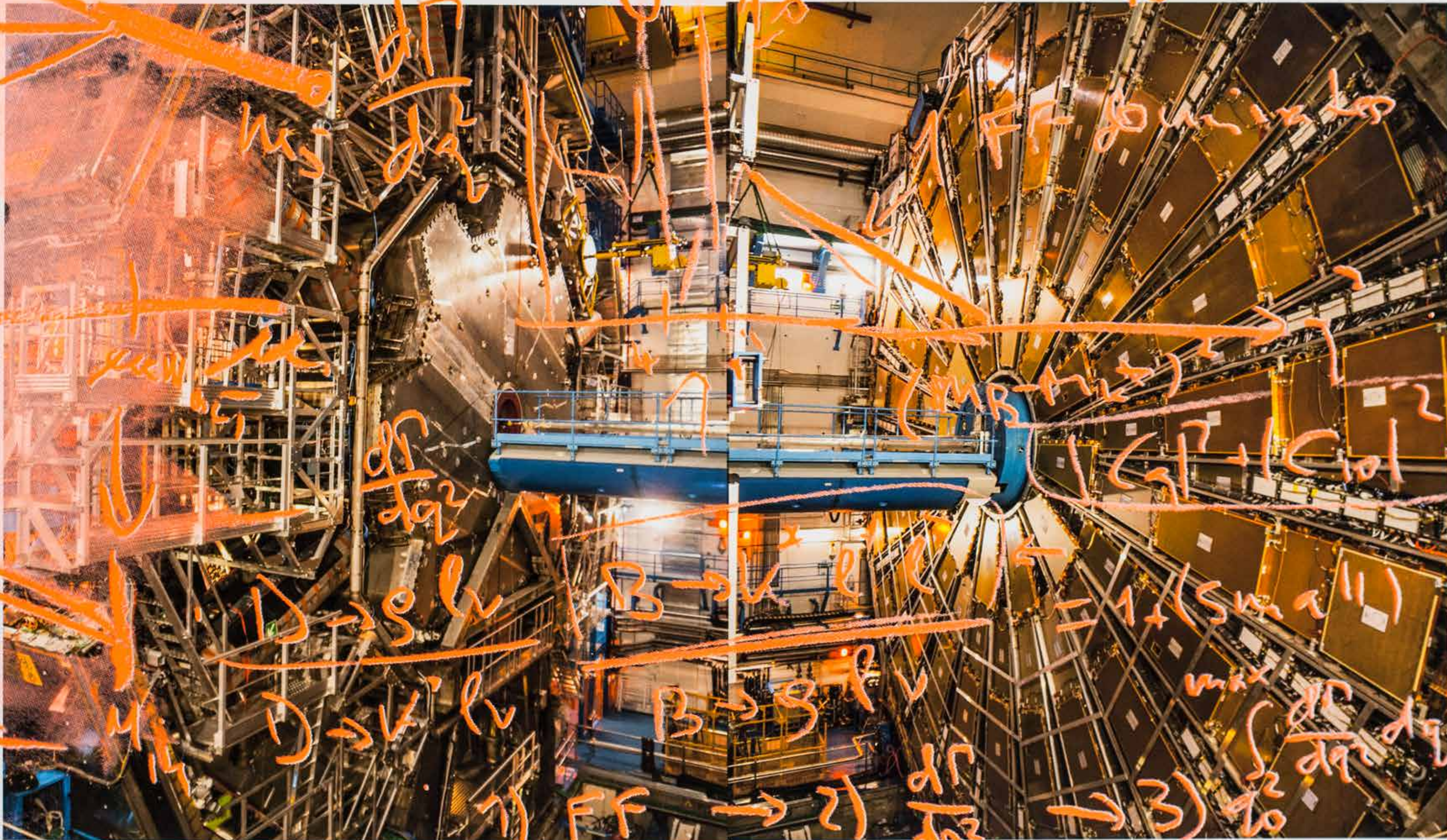
Of all the known forms of energy, perhaps the most mysterious is electricity. Electrons, its primary carrier, were not even discovered until 1897. Very shortly thereafter we welcomed it into our homes; cities first, and then the countryside became electrified. Fast-flowing rivers of these subatomic particles were summoned to do our bidding: to provide light, to run appliances, to give life to devices that entertain us. Previously arduous tasks became easier. But more importantly, we invented uses for electricity in society that were undreamt of in any previous generation.

To harness and command the behavior of electricity requires wires. Lots of them. Going everywhere. Think about it: for every electrical appliance you plug into the wall, there's a

continuous connection of wires from the on-switch of your device to a far-off power plant, generating your electricity from sources of energy not otherwise directly useful to you, such as wind, hydro, solar, nuclear, coal, or other fossil fuels. If every device connects to wires, and all wires lead to the power plant, and everybody wants electricity, that's the recipe for a Gordian tangle of wires. Yes, they're everywhere, wherever there are people. From the wires that power hillside towns in Brazil to the wires that power the world's largest particle accelerator in Switzerland, they're all conduits for electrons to surf the countryside along their appointed paths.

The wires are either buried underfoot so you don't know they're there, or hidden in plain sight, as a kind of wallpaper backdrop of our landscape for living. Like Joyce Kilmer's famous poem, which forced us all to pause as we reflect on a tree's beauty that would otherwise go unnoticed, so too is our power grid something to behold, but only if someone compels you to take notice. That's the job of an artist.

It's time to marvel at the intersection of our ever-increasing demand for power and the ever-growing impact of that need on our environment. It's time to elevate electricity to art. And it's time to remind ourselves,



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about energy. There, the chaotic need for basic resources manifests itself as visual spaghetti, in tangles of electrical wires. Rocinha is a sprawling city unto itself precariously pitched down a mountainside with incomparable vistas of the sea. To walk freely around this favela of uncontrolled growth requires permission from the ruling drug lords to navigate the labyrinth of alleys where spider webs of electrical wires go in every direction. Residents who risk electrocution to tap into this unregulated system, unknowingly make expressive drawings in space.

As an artist, I'm drawn to the gestures of Jackson Pollock, and these electrical wires had the same look of urgency that I saw in the art I admired. Photography seemed the only way to capture these "drawings," partly because the physical conditions of Rocinha meant camera work while shooting on the run. In the configuration of these wires, I saw a world of conflicting needs and human entanglement. This visual chaos beautifully reflects a baseline need for flowing energy. It was in Rocinha that I came to understand the place where the challenging circumstances of survival meet our planet's environmental destruction.

Prior to my first foray to Brazil in 2005 and visits to CERN, I had no idea that a project about energy was about to begin. In 2000, I accepted an invitation to visit Brookhaven National Laboratory in New York where I

was introduced to scientists of the Relativistic Heavy Ion Collider, whose research revolved around splitting off the proton beam line of the collider to shoot protons through a latticework of crystallized human protein. The X-ray crystallography images of future Nobel Laureate, Rod MacKinnon, introduced me to the "electricity" inside the human body where charged salt ions move across cell membranes. Little did I know that this interest in images and energy would be a theme sustained for twenty years, manifested across three continents, and would result in three books.

*Surfing the Cosmos* is my most recent book about energy, which is essential to the human condition. As the ecologist Carl Safina noted, "We, the living, must be continually plugged into flowing energy and flowing materials. Animals such as we are like bonfires. Stop providing energy and material (food, fluid, and air), and we not only go out, we cease to exist." The imagery in *Surfing the Cosmos* scratches the surface of the complexity and beauty of human energy. The graphic gestures in the wires of Rocinha tell a compelling story of the human condition interwoven with global warming. Science allows us to better understand the problem with the promise of solutions. Like the wires of Rocinha, the lines on the chalk boards at CERN represent the urgency of our quest to tap into energy's source. The samba with science continues.

**Steve Miller**



$T_{ds} \sim \frac{1}{R} \sim \frac{1}{\Lambda} \sim \frac{1}{\sqrt{\Lambda^2}}$

Quantum system with FINITE # of states  
 $\rho \sim (MP)^2 \sim \frac{1}{\Lambda^2}$   
 Particles of BHs  
 unstable in ds

Global coord.  $S \rightarrow$  compact  
 $\rightarrow$  total  $Q=0$   
 Static Patch  $\rightarrow$  Cosmological Horizon  
 $\rightarrow$  Screen Image  
 only apparent charge  $\rightarrow$  total charge  $Q=0$

excitations of ds space  
 Nonlocal Mechanism ds Adjusting itself

Zoom into the vicinity



Derive BKI  
 $N < N^*$   
 $R/d_s \sim \lambda^{1/4}$   
 $R \sim \lambda^{1/4}$   
 $L \sim N^c$   
 $X = \beta L^c$   
 $L(c) = \ln(L+1)$   
 $L(x) = \ln(x+1)$

Exactly N-finite system  
 Recursive Solns? Moments?

Consistency of Overlapping Observers

C.D. Universeness



The Finiteness of Quantum Universe

Holography



$S^1(2) = H.S$   
 $L(x) = \ln(x+1)$   
 $L(x) = \ln(x+1)$   
 $L(x) = \ln(x+1)$

