

THE INFORMATION PARADOX

WHY BLACK HOLES COULD DELETE THE UNIVERSE

BLACK HOLES IN A NUTSHELL

A black hole is an extraordinary amount of mass concentrated in a tiny space. Nothing, not even light, can escape black holes after it crosses the event horizon. This completely separates black holes from the rest of the universe: once in, we cannot exit. We do not know what goes on inside black holes, but we think

we know what happens just outside: black holes radiate their mass away, like a pot of boiling water losing water as steam. This is Hawking radiation, and results in black holes slowly evaporating. But there is a problem: in the process of disappearing, black holes might delete something very fundamental: information.

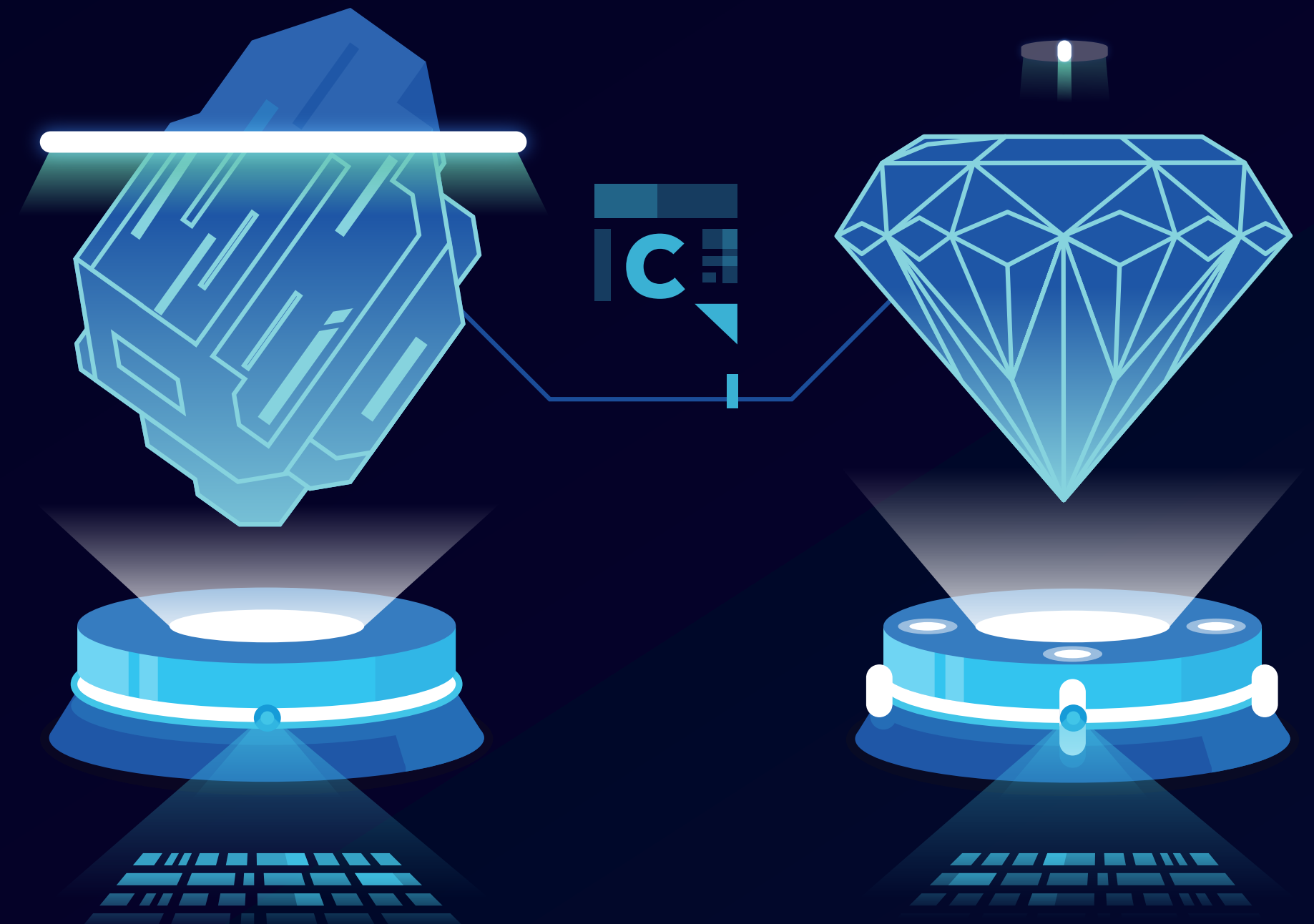


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INFORMATION & PARADOX

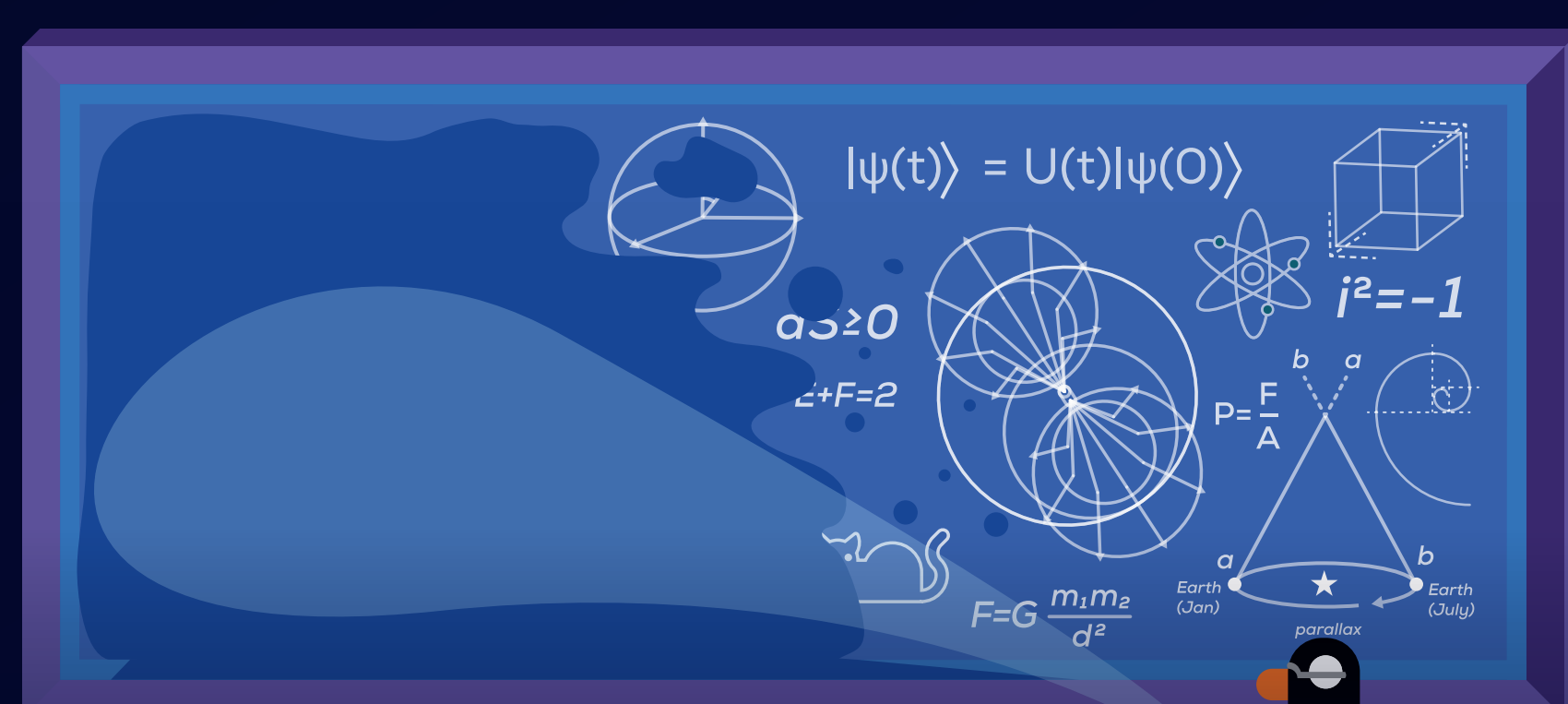


Information is a property of the arrangement of things. For example, a bunch of carbon atoms arranged in one way is coal. Arranged in another way, it is a diamond. The two objects are made of the same material; the information is different. Without information, everything in the universe would be the same. Information is crucial and,

according to quantum physics, indestructible. But black holes take different things and make them the same, destroying information in the process. This is a paradox: black holes and quantum physics seem to be incompatible—but both exist in our universe! Physicists have been trying to make sense of this for decades, and there are several options.

POSSIBLE SOLUTIONS

1. INFORMATION IS LOST



This means we have to throw out all our laws of physics, giving up lots of things that worked very well so far, to start from scratch. It is hard to say what the new laws of physics would look like or what this means for us. This might be a little frightening, but also kind of exciting.

2. INFORMATION IS HIDDEN

One compromise is to say that information is not lost: it is just somewhere we cannot access. Perhaps black holes leave behind a concentrated gem of information before disappearing—an information diamond—or store it somewhere else. But this is not much different from losing the information, if we cannot do anything with it.



3. INFORMATION IS SAFE

If we take quantum physics seriously, information must be conserved. But where does it go then? If we throw something in a black hole, it gets bigger. And for any bit of information we throw in, the black-hole surface increases by a tiny pixel. It is as if the information is stored on the surface, like a hologram.

This is the holographic principle and is a way out of the information paradox. But if correct this also means that the universe is a strange place: a three-dimensional person, like you and I, can be flattened out on a screen, and all their lives could be described as a movie on that screen.

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THE PROJECT BEHIND THIS POSTER
This poster is part of the project "A voyage to the boundary of theoretical physics" realised within the Agora scheme of the Swiss National Science Foundation and coordinated by Dr. Alessandro Sfondrini of ETH Zurich. Our goal is to give students a taste of what current research in theoretical physics is about and how it is actually performed, dispelling some of the prejudices surrounding this field of science. You can learn more on the project at www.physdocu.ethz.ch