



© 1997–2009, Millennium Mathematics Project, University of Cambridge.

Permission is granted to print and copy this page on paper for non-commercial use. For other uses, including electronic redistribution, please contact us.

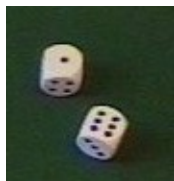
September 1998

News

Why God plays dice



"*God does not play dice*" Albert Einstein once said, expressing his contempt for the notion that the universe is governed by probability – an idea fundamental to quantum theory (see "[Quantum uncertainty](#)" in Issue No 5). Since then the undisputable successes of the quantum theory have convinced all but a handful of contemporary physicists that God does indeed play dice. The question some physicists are now asking is *why* does God play dice? What's the point? Popescu, a Cambridge physicist, believes he has the beginnings of an answer to this seemingly monumental question.



There's now no doubt that God plays dice, but why *should* our universe be probabilistic at all?

"*Quantum entanglement*" is the term used to describe the bizarre link that may develop between two or more particles, even when they are separated by cosmological distances. A photon may decay into an electron and a positron (the positron being the *antiparticle* of the electron). Electrons and positrons possess an observable quantity called *spin*, a kind of internal angular momentum, which when measured in some direction will either be "up" or "down". According to quantum mechanics, if one measures say the electron spin to be "up" in some direction, at that very instant the spin of the positron will be "down" in the same direction, no matter how far apart the particles. This poses a serious problem: according to relativity, no signal can travel faster than light, the "speed limit of the universe". Imagine it; we could measure the electron spin here on earth, and instantaneously the positron, which could be in another galaxy, would "know" which direction its spin should point. Weird.

Popescu believes he can resolve this apparent paradox between the two theories. He believes that God "plays dice" precisely to allow quantum theory and relativity theory to coexist.

Why God plays dice



Plus is part of the family of activities in the Millennium Mathematics Project, which also includes the NRICH and MOTIVATE sites.