Does God play dice with the Universe?

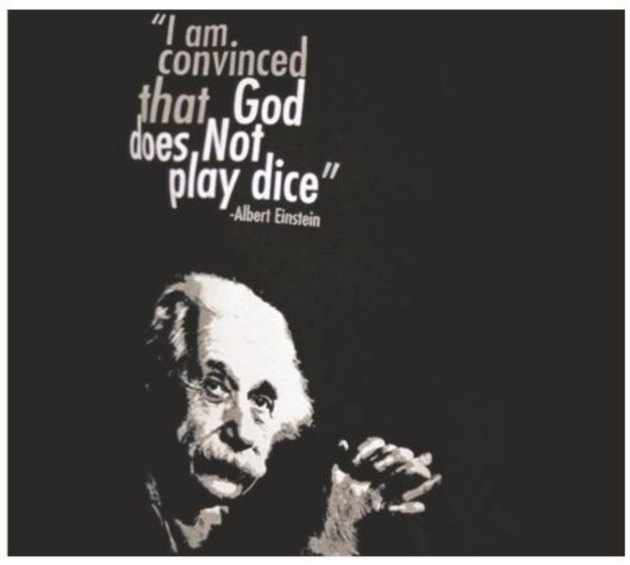
QUAMRUL HAIDER, *Ph.D*

AT the end of the nineteenth century, scientists were convinced that we knew whatever there was to know about the mysteries of Nature. This conviction was based on our unflinching faith on Newton's laws of motion and his universal theory of gravitation. In the words of British poet Alexander Pope, "Nature and Nature's law lay hid in night; God said let Newton be! And all was light." These laws together with Maxwell's theory of electro-magnetism, laws of thermodynamics, and kinetic theory of gases provided causal interpretations for the behavior of all objects in the Universe. They form the basis for what we call "classical physics."

The bedrock of classical physics is the aphorism of a *deterministic Universe,* a Universe where every observable can be simultaneously measured to any level of accuracy. Our dogmatic belief in the deterministic nature of classical physics remained unchallenged for more than 200 years. Things, however, changed at the turn of the twentieth century when discoveries of electrons, protons, neutrons, X-rays, radioactivity, etc. gave us the first glimpse of the denizens of subatomic world.

The path to quantum mechanics began when experiments to study the spectrum of thermal radiation, emission of electrons from surfaces illuminated with light, and scattering of X-rays by electrons presented us with new and puzzling results concerning the properties of matter and radiation. These experiments not only exposed the inadequacy of classical physics to explain phenomena at the microscopic level, they also profoundly influenced our perspective of the Universe.

Within a short span of time, two decades to be precise, quantum mechanics was developed to study the microscopic world. The basic tenet of quantum mechanics was provided in 1900 by the "reluctant revolutionary" Max Planck. He postulated that electromagnetic radiation is quantized and occurs in finite packets of energy called photons which are *massless particles* travelling at the speed of light. Likewise, Louis deBroglie hypothesized that particles at the microscopic level should exhibit *wave-like properties.*



The bold theories that were advanced and the revolutionary notion of dual property of matter and radiation as waves and particles, respectively, rendered Newton's concept of deterministic nature of particle, space, and time redundant in the microscopic domain. Instead, it was replaced by quantum theories based on the probabilistic nature of measurements, implying certain amount of fuzziness or uncertainty in the description of reality. The excitement of the era was described by Einstein "as a marvelous time to be alive."

In 1927, the probabilistic precept of quantum mechanics introduced a new level of reality in physics - Heisenberg's Uncertainty Principle. According to the principle, "Events at the microscopic level occur randomly, by pure chance meaning that they aren't determined by any cause whatsoever." Simply stated, at the incredibly small dimensions of the quantum world, there is a reciprocal uncertainty between position and velocity. If an electron's position, for example, is measured with high precision, measurement of its velocity would be imprecise, and vice-versa. Furthermore, we won't be able to predict with certainty where the electron would be when a next attempt is made to measure its position. These restrictions are not a result of errors in making measurements; they are fundamental limitations imposed by the idiosyncrasies of the Universe

The view that Nature is governed by probability rather than certainty flustered many scientists, including Einstein. According to him, the Universe was deterministic in the sense that every event that occurs is caused by other events in such a way that the causing events bring about their effects. He presumed that "God created Newton's laws of motion and the necessary masses and forces. That is all; everything else follows by deduction upon development of suitable mathematical methods."

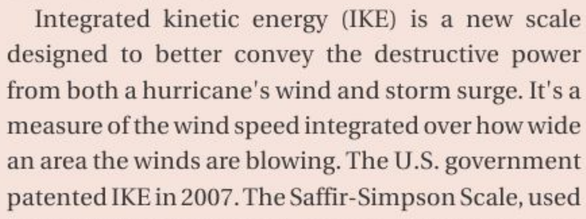
Although he was well aware that quantum mechanics had survived stringent experimental tests, Einstein believed that if it "were correct then the world would be crazy." Flamboyant Nobel physicist Richard Feynman was frank enough to admit, "I think I can safely say that nobody understands quantum mechanics." True, we don't understand it; but we got inured to it.

The advocates of quantum indeterminacy deemed that the probabilistic mathematics of quantum mechanics is due to the failure of causality in reality. They analogized that behavior of the Universe, particularly at the atomic level, is similar to God playing dice with it. Einstein retorted, "God does not play dice with the Universe." Danish physicist Niels Bohr argued instead that Nature is apathetic to our preconceptions. His advice to Einstein was: "Stop telling God what to do." Cosmologist Stephen Hawking thinks, "Einstein was wrong when he said 'God does not play dice.' Consideration of black holes suggests, not only that God does play dice, but that he sometimes confuses us by throwing them where they can't be seen."

The writer is a Professor of Department of Physics & Engineering Physics, Fordham University, New York.

SUPERSTORM

Sandy second worst storm



This GOES-13 satellite image was captured on Oct. 31 at 1240 UTC as Sandy's circulation was winding down over Pennsylvania.

IN sheer power, Hurricane Sandy ranks second among modern hurricanes, beating even Hurricane Katrina, according to Brian McNoldy, a hurricane researcher at the University of Miami.

Out in the Atlantic Ocean, Sandy was the most energetic tropical cyclone in history, thanks to its massive wind field.

Once Sandy ramped up to a Category 1 hurricane and slammed into New Jersey, the storm's integrated kinetic energy was second only to Hurricane Isabel in 2003, McNoldy wrote in a blog post.

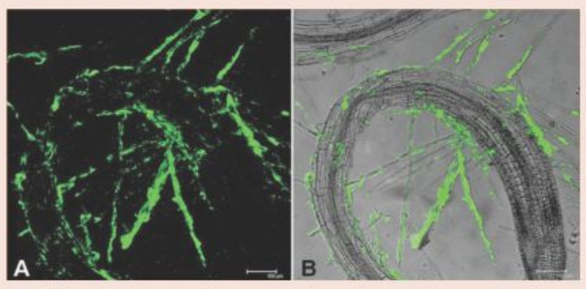
"It stood out to me that this was a pretty unique case of a rather weak storm as wind speeds go, but huge on the impact scale," McNoldy told OurAmazingPlanet.

Integrated kinetic energy (IKE) is a new scale designed to better convey the destructive power from both a hurricane's wind and storm surge. It's a measure of the wind speed integrated over how wide an area the winds are blowing. The U.S. government patented IKE in 2007. The Saffir-Simpson Scale, used by the National Weather Service, only reports top wind speeds.

Source: **Live Science**

BACTERIA POWER

Bacteria to resist drought



Plant root colonization experiments performed with a Klebsiella pneumoniae strain isolated from the pepper rhizosphere genetically labeled with a gfp. (A) and (B) colonization of Arabidospis thaliana rhizoplane.

WHEN there is little water available for plants to grow, their roots form alliances with soil microbes that can promote plant growth even under water-limiting conditions, according to research published Oct. 31 by Daniele Daffonchio and colleagues from the University of Milan, Italy in the open access journal PLOS ONE.

Symbiotic relationships between plants and soil microbial communities are critical to the health of plants. Though the effects of drought on plants are well-known, little is known about how lack of water affects the bacteria around plant roots.

In this study, the researchers grew pepper plants under conditions of limited water and analyzed the bacterial species around the roots of the plants. They found that drought stress enriched the microbial communities with bacteria capable of increasing plant photosynthesis and biomass production by up to 40% under limited water conditions.

According to Daffonchio, ""Our findings highlight that fully functional plants cannot be considered single organisms anymore, but meta-organisms of the plant and its microbiome, which promotes essential functions like resistance to water stress. The promotion of drought resistance by bacteria can have important applications, for instance, in retaining high yields from plants even in the presence of lower irrigation. "

SOURCE: **SCIENCE DAILY**

OUTSIDETHEBOX

Hunting dark matter with DNA

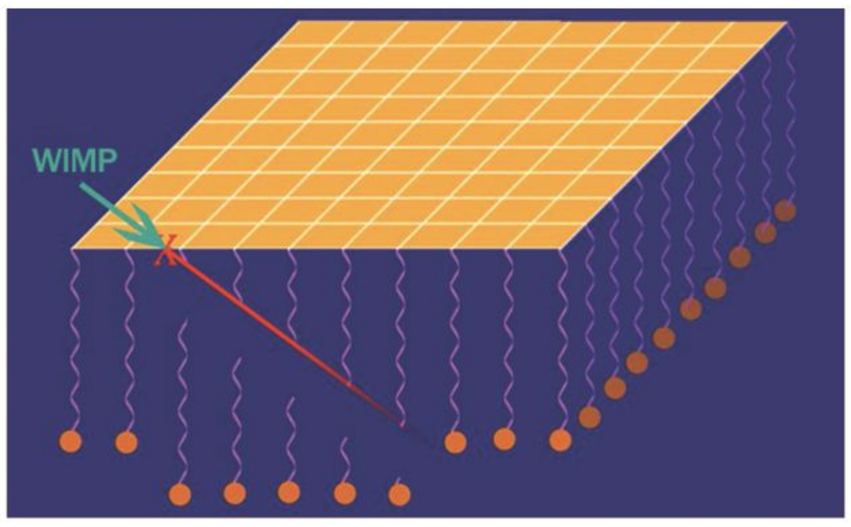
PHYSICISTS racing to detect the mysterious substance known as dark matter are thinking outside the box by looking inside the cell. A new proposal for tracking dark matter particles relies on strands of DNA.

All the ordinary stuff in the universe, from the atoms in people to the hot plasma in stars, makes up only about 5 percent of the universe's mass and energy. Nearly one-quarter of the universe is composed of dark matter. (The rest is an even more puzzling entity known as dark energy.) Though several experiments claim to have detected dark matter, the results don't agree and aren't definitive.

Katherine Freese, a theoretical physicist at the University of Michigan in Ann Arbor, proposed October 28 at the New Horizons in Science meeting that a new kind of DNA-based detector could not only spot a leading candidate for dark matter, called WIMPs, but could also determine incoming particles' direction of flight. The proposal also appeared online earlier this year at arXiv.org.

"It's a very smart way to apply technology developed from biology to a fundamental particle physics problem," says Jocelyn Monroe, a dark matter physicist at MIT and the University of London.

A halo of WIMPs, short for weakly interacting massive particles, is thought to encircle the galaxy. As the sun orbits the galaxy's center, it should encounter a "wind" of WIMPs from the direction of the constellation Cygnus. At any point on Earth, such a wind should strengthen and weaken daily as the planet rotates.



In a proposed method for detecting dark matter, particles of dark matter would smack into gold, kicking off atomic nuclei that would sever strands of DNA in their paths.

Freese and her colleagues' proposed detector, which would be sensitive to these fluctuations, consists of a stack of thin gold sheets with single-stranded pieces of DNA hanging from them. When a WIMP smacked into the nucleus of a gold atom, the nucleus would whiz off, cutting through the DNA at specific locations in the strands.

Scientists would then collect and sequence the DNA to reconstruct the path traveled by the nucleus, and by extrapolation, that of the WIMP. If the detector spotted the daily fluctuation and the particles' paths proved consistent with the WIMP wind's direction, it would be compelling evidence that the signals came from dark matter.

"The advantage of these detectors is that the difference between DNA bases is a nanometer, so it's much better resolution," says Freese about a thousand times better than current detectors.

The device could be a fraction of existing detectors' size, as well as cheaper.

Still, the technique has yet to be demonstrated, says Joel Schnur, a biomolecular scientist at George Mason University in Fairfax, Va. "What is the real sensitivity to cleavage of DNA? How many particles will come down over time? And, can it detect them?" he asks.

If the project goes forward, Freese and colleagues could begin to answer some of these questions.

Source: **Science News**

BOTH AT A TIME

Wave-particle duality tested

SURPRISINGLY, when a photon is observed, it behaves either as a particle or as a wave. But both aspects are never observed simultaneously. In fact, which behaviour it exhibits depends on the type of measurement it is presented with. These astonishing phenomena have been experimentally investigated in the last few years, using measurement devices that can be switched between wave-like and particle-like measurements.

In a paper published Nov. 1 in Science, physicists from the University of Bristol give a new twist on these ideas. Dr Alberto Peruzzo, Peter Shadbolt and Professor Jeremy O'Brien from the Centre for Quantum Photonics teamed up with quantum theorists Dr Nicolas Brunner and Professor Sandu Popescu to devise a novel type of measurement apparatus that can measure both particle and wave-like behaviour simultaneously. This new device is powered by quantum nonlocality, another strikingly counter-intuitive quantum effect.

Dr Peruzzo, Research Fellow at the Centre for Quantum Photonics, said: "The measurement apparatus detected strong nonlocality, which certified that the photon behaved simultaneously as a wave and a particle in our experiment. This represents a strong refutation of models in which the photon is either a wave or a particle."

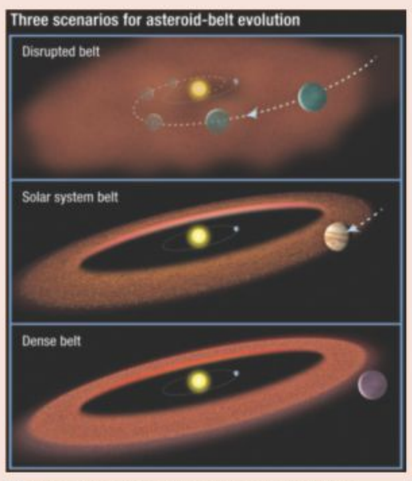
Professor O'Brien, Director of the Centre for Quantum Photonics, said: "To conduct this research, we used a quantum photonic chip, a novel technology pioneered in Bristol. The chip is reconfigurable so it can be programmed and controlled to implement different circuits. Today this technology is a leading approach in the quest to build a quantum computer and in the future will allow for new and more sophisticated studies of fundamental aspects of quantum phenomena."

Source: **Science Daily**

Photons, particles of light, are both particles and waves simultaneously. Physicists now give a new demonstration of this wave-particle duality of photons.

RARITY'S THEWORD

Life on asteroid belt



Three possible scenarios for the evolution of asteroid belts.

Source: **Live Science**

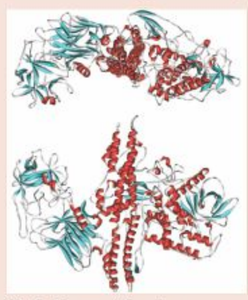
Asteroid belts similar to the one between Mars and Jupiter appear to be rare beyond our solar system, implying that complex alien life may be rare as well, a new study reports.

Fewer than 4 percent of known alien solar systems are likely to have an asteroid belt like the one in our own neck of the woods, researchers found. Belts that look like ours may help spur the evolution of life, seeding rocky planets with water and complex chemicals but not pummeling the worlds with a constant barrage of violent impacts.

"Our study shows that only a tiny fraction of planetary systems observed to date seem to have giant planets in the right location to produce an asteroid belt of the appropriate size, offering the potential for life on a nearby rocky planet," study lead author Rebecca Martin, of the University of Colorado in Boulder, said in a statement. "Our study suggests that our solar system may be rather special."

DID YOU KNOW?

What is the strongest poison?



Botulinum Toxin

Botulinum Toxin, is the most acutely toxic substance known. A mere 90-270 nanograms of botulinum toxin could be enough to kill an average 90 kg (200 lb) person.

Botulinum toxin (abbreviated either as BTX or BoNT) is a protein and produced by Clostridium botulinum, a gram-positive anaerobic bacterium. The clinical syndrome of botulism can occur following ingestion of contaminated food, from colonization of the infant gastrointestinal tract, or from a wound infection.

BoNT is broken into 7 neurotoxins (labeled as types A, B, C [C1, C2], D, E, F, and G), which are antigenically and serologically distinct but structurally similar. Human botulism is caused mainly by types A, B, E, and (rarely) F. Types C and D cause toxicity only in animals.