SOLAR SYSTEM: SURFING THE EDGE OF CHAOS

WAYNE HAYES
(Univ. of California at Irvine)

The stability of our Solar System has been debated since Newton devised the laws of gravitation to explain planetary motion. Newton himself doubted the long-term stability of the Solar System, and the question has remained unanswered despite centuries of intense study by generations of illustrious names such as Laplace, Langrange, Gauss, and Poincare. Finally, in the 1990s, with the advent of computers fast enough to accurately integrate the equations of motion of the planets for billions of years, the question has finally been settled: for the next 5 billion years, the shapes of the planetary orbits will remain roughly as they are now. This is called "practical stability": none of the known planets will collide with each other, fall into the Sun, or be ejected from the Solar System, for the next 5 billion years.

Although the Solar System is now known to be practically stable, it may still be "chaotic". This means that we might —or might not— be able to predict their precise positions within their orbits, for the next 5 billion years. The precise positions of the planets can affect the tilt of each planet's axis, and so can have a measurable effect on the climate. For the past 15 years, there has been debate about whether the Solar System exhibits chaos or not: when performing accurate integrations of the planetary motions, some astronomers observe chaos, and some do not. This is particularly disturbing because it is known that inaccurate integration can inject chaos into a numerical solution that would otherwise be stable.

My research is numerical analysis, and in this talk I will demonstrate how I closed the 15-year debate on chaos in the solar system by performing the most accurate, long-term integrations of the orbits of the planets that has ever been done. The answer surprised even the astronomical community, and was published in Nature Physics.