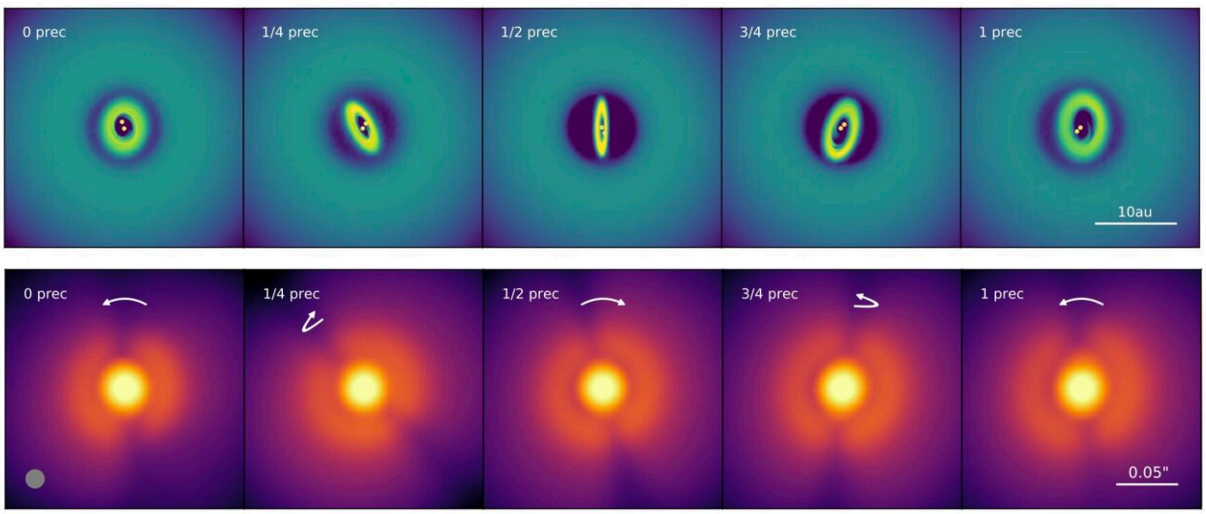
Examining rocking shadows in protoplanetary disks

July 15 2022



This is a still from a simulation of a forming planetary disk, made by University of Warwick and Stephen Hawking Research Fellow Rebecca Nealon. The images show the rotating inner disk along the top half, and the shadow it casts on the outer disk in the lower half. Credit: Rebecca Nealon / University of Warwick

Astronomers from the University of Warwick reveal a new phenomenon dubbed the "rocking shadow" effect that describes how disks in forming planetary systems are oriented, and how they move around their host star. The effect also gives clues as to how they might evolve with time. Dr. Rebecca Nealon presented the new work this week at the 2022 National Astronomy Meeting at the University of Warwick.

Stars are born when a large cloud of gas and dust collapses in on itself. The leftover material that doesn't make it into the star ends up circling around it, not unlike how water swirls around the drain before falling in. This swirling mass of gas and dust is called a protoplanetary disk, and it's where planets like the Earth are born.

Protoplanetary disks are often thought to be shaped like dinner plates—thin, round and flat. However, recent telescope images from the Atacama Large Millimeter/Submillimeter Array (ALMA) show that this is not always the case. Some of the disks seen by ALMA have shadows on them, where the part of the disk closest to the star blocks some of the stellar light and casts a shadow onto the outer part of the disk. From this shadow pattern, it can be inferred that the inner part of the disk is oriented completely differently to the outer part, in what is called a broken disk.

In this research, the team used high performance computers to run three-dimensional simulations of a broken disk. The team then produced a mock observation, modeling what such a disk would look like if it were to be observed through a telescope, and how it would change over time.

As the inner disk moved through the gravitational pull of the central star, the shadow it cast moved across the outer disk. But instead of the shadow pattern moving around the disk like a clock-hand as expected, it rocked back and forth with a see-saw-like motion. So although the inside disk kept turning in the same direction, its shadow looked like it was rocking forwards and backwards. The team suggest this is caused by a geometric projection effect, which is likely to occur in all broken disks.

Nealon says that "JWST promises to give us a look at embryonic planetary systems in unprecedented detail, and with our new models we'll be able to find out a lot more about the birth of planets."

More information: Conference: nam2022.org/

Provided by Royal Astronomical Society