IN THE NEWS

A space chronometer

Much like marine chronometers were essential for sea navigation, portable time standards will be needed for deep space navigation. Current missions rely on communication with Earth, where accurate time-keeping is done with state of the art atomic clocks. However, communication becomes slower as spacecraft go farther into the Solar System.

Future missions will need their own version of a space chronometer and this is why NASA's Jet Propulsion

Laboratory developed a mercury ion clock, the Deep-Space Atomic Clock (DSAC), part of the Department of Defense Space Technology Program 2. The clock was launched into space on board a SpaceX Falcon Heavy rocket on June 24. It will spend 1 year on board a General Atomics' Orbital Test Bed spacecraft in low-Earth orbit for in-flight operation testing.

Atomic clocks are delicate devices, so it is very challenging to make them robust enough to withstand a launch and operate in an environment with large temperature and magnetic field fluctuations. It took over 5 years to get the current DSAC demonstration unit ready to fly. The entire instrument weighs 16 kg. The actual clock is about the size of a large shoe box and is designed to operate continuously and autonomously with low power consumption. Over 10 million mercury ions are trapped in an ion trap, which is sealed in a vacuum tube. Compared with the glass cells containing rubidium vapour used in the atomic clocks on GPS satellites, the confinement in the ion trap considerably reduces the ion

collisions with the walls, which lead to clock instabilities. In addition, the mercury ion clock transition ticks at an approximately six times higher rate than the rubidium clock transition, improving performance in an environment with high magnetic field fluctuations. The DSAC should therefore be 50 times more stable than the global positioning system (GPS) rubidium clocks.

The DSAC design stability is better than 2 ns per day, but its developers hope to reproduce the laboratory results of 0.3 ns per day. The team will also conduct an analogue deep space navigation experiment mimicking the tracking of a spacecraft in Mars orbit. This experiment will test the DSAC potential for future deep space navigation. "The DSAC will be the first ever ion clock to fly in space and promises to revolutionize the way we navigate and explore deep space," says Todd Ely, principal investigator of the DSAC Technology Demonstration Mission. "We expect to learn a lot from the space demonstration, and using that experience and the lessons learned over the years we expect to be able to design a long-life (10 year version) of DSAC in just a few years following the DSAC mission."

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Credit: NASA