Jet Propulsion Laboratory
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π IN THE SKY 8

Collect samples from an asteroid, fly the first helicopter on Mars, find new ways to talk to distant spacecraft, and study the forces behind Earth's auroras. NASA solves these real problems to explore space and Earth – and so can you!

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SAMPLE SCIENCE

NASA's OSIRIS-REx mission was designed to travel to an asteroid called Bennu and bring a small sample back to Earth for further study. To achieve its mission, the spacecraft needed to make contact with 26 cm^2 of asteroid Bennu's surface and collect millimeter-size particles using its "contact-pad samplers." These are 1.5-centimeter diameter circular pads of Velcro-like stainless steel. There are 24 pads on the mechanism designed to collect the samples.

How many pads needed to make contact with Bennu's surface to meet the mission requirement?

If all 24 pads contacted Bennu, how much asteroid surface area would the contact pads sample?

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nasa.gov/osiris-rex

WHIRLING WONDER

Joining the Perseverance rover on Mars is a small helicopter named Ingenuity. With twin counter-rotating blades spanning 1.2 meters, Ingenuity is a test of new technology and is designed to achieve the first powered flight on another world.

Despite Mars having less gravity than Earth, the atmosphere on the Red Planet is much thinner than it is here on our home planet. This makes it challenging to lift off the ground on Mars. To generate enough lift for Ingenuity, engineers determined that the helicopter's blades need to rotate at approximately 250 radians per second on Mars.

How fast – in rotations per minute – do Ingenuity's blades spin?

How does that compare to a typical helicopter on Earth with blades that spin at 500 rotations per minute?

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mars.nasa.gov/mars2020

SIGNAL SOLUTION

As more and more data are collected and transmitted through space, NASA needs new technologies to communicate faster and more efficiently with its spacecraft. One such technology is called Deep Space Optical Communications, or DSOC, which uses near-infrared light instead of radio waves to transmit a signal. This allows us to use a higher frequency (shorter wavelength) so more data can be transmitted per second.

The twin Voyager spacecraft launched in 1977 use a 12.5 watt transmitter paired with a parabolic reflector that creates a circular radio signal with a diameter roughly 0.5 degrees wide. A DSOC system would use a 4 watt transmitter on a flight laser transceiver, producing a light signal with a diameter of 0.0009 degrees.

If Voyager and a DSOC-equipped spacecraft were both placed 124 AU from Earth (1 AU = 150,000,000 km) what fraction of each original wattage would be received by a 70 meter antenna on Earth?

By what factor is DSOC more effective?

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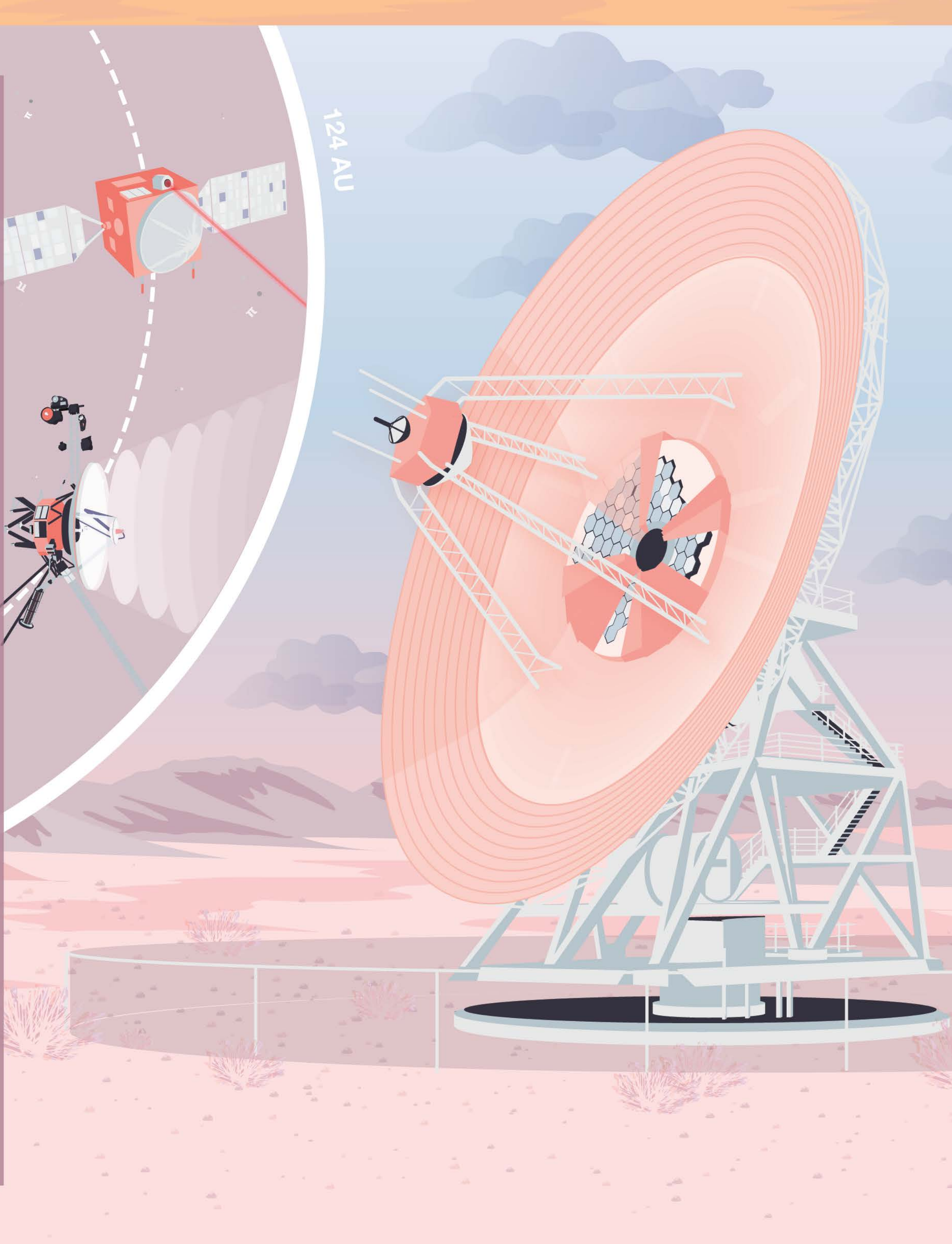
go.nasa.gov/2Lnrv8o



FORCE FIELD

Every day, Earth is showered in radiation from the Sun. The Sun also emits charged particles almost entirely in the form of ionized hydrogen and helium. These ions travel at speeds of about 400 km per second but rarely reach Earth's surface. That's because they are deflected by Earth's magnetic field due to the Lorentz force, given by the equation: $F = qvB\sin\theta$ where F = force (N), q = charge of the particle in coulombs (C), v = velocity of the particle in meters per second (m/s), B = the magnetic flux density of Earth's magnetic field in teslas (T) and θ in radians. The charged particles can't cross Earth's magnetic field, so they follow it to the North and South poles. The resulting concentration of charged particles is what creates auroras.

If Earth's magnetic flux density is 60μT, what force would a hydrogen ion observe at π/4 radians from the equator? What about at the North Pole (π/2 radians)?

Does the relative magnetic field agree or disagree with what you'd expect about the location of auroras?

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