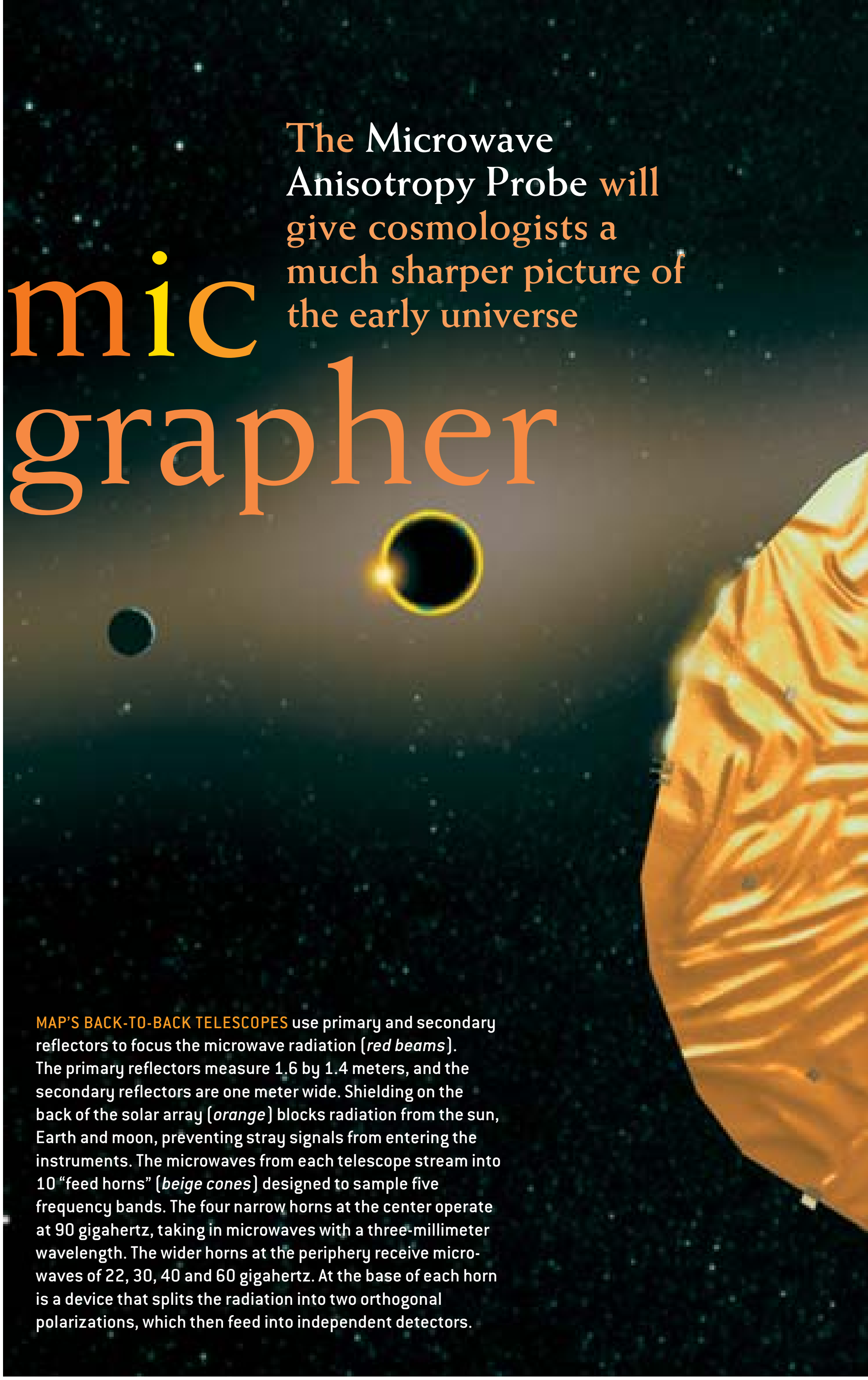
DESTINY

a cosmic cartographer

The Microwave Anisotropy Probe will give cosmologists a much sharper picture of the early universe

BY CHARLES L. BENNETT, GARY F. HINSHAW AND LYMAN PAGE



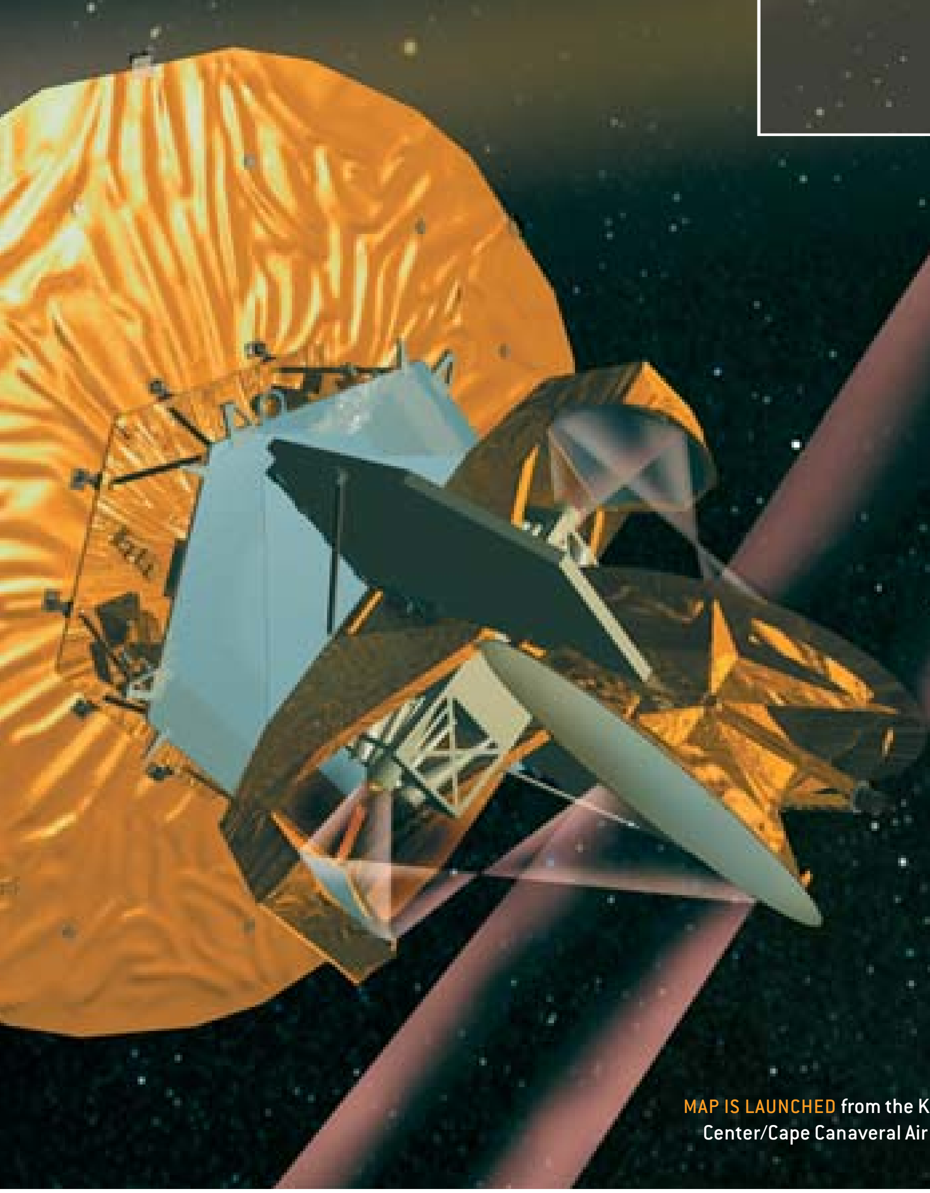
MAP'S BACK-TO-BACK TELESCOPES use primary and secondary reflectors to focus the microwave radiation (*red beams*). The primary reflectors measure 1.6 by 1.4 meters, and the secondary reflectors are one meter wide. Shielding on the back of the solar array (*orange*) blocks radiation from the sun, Earth and moon, preventing stray signals from entering the instruments. The microwaves from each telescope stream into 10 "feed horns" (*beige cones*) designed to sample five frequency bands. The four narrow horns at the center operate at 90 gigahertz, taking in microwaves with a three-millimeter wavelength. The wider horns at the periphery receive microwaves of 22, 30, 40 and 60 gigahertz. At the base of each horn is a device that splits the radiation into two orthogonal polarizations, which then feed into independent detectors.

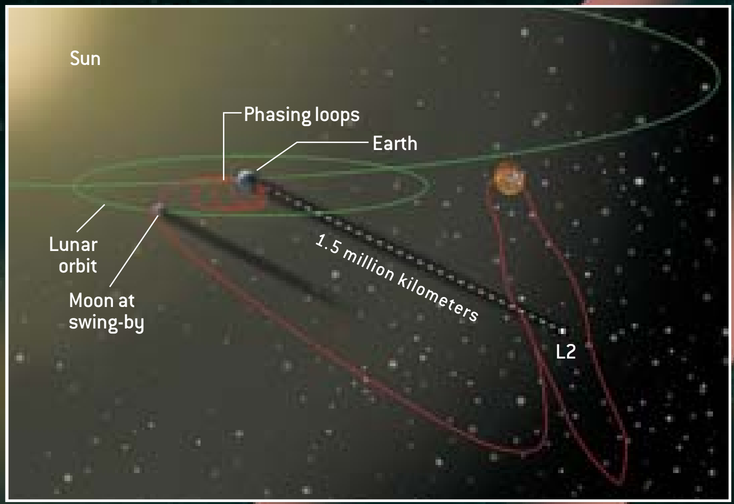
On June 30, 2001, NASA launched a Delta 2 rocket carrying an 840-kilogram, four-meter-high spacecraft. Over the next three months the Microwave Anisotropy Probe (MAP) maneuvered into its orbit around the sun, 1.5 million kilometers beyond Earth's orbit. MAP is now observing the cosmic microwave background (CMB) radiation in exquisite detail over the entire sky. Because this radiation was emitted nearly 15 billion years ago and has not interacted significantly with anything since then, getting a clear picture of the CMB is equivalent to seeing a map of the early universe. By studying this map, scientists can learn the composition, geometry and history of the cosmos.

MAP is designed to measure the anisotropy of the CMB—the minuscule variations in the temperature of the radiation coming from different parts of the sky. MAP can record fluctuations as small as 20 millionths of a kelvin from the radiation's average temperature of 2.73 kelvins. What is more, the probe can detect hot and cold spots that subtend less than 0.23 degree across the sky, yielding a total of about one million measurements. Thus, MAP's observations of the CMB will be far more detailed than the previous full-sky map, produced in the early 1990s by the Cosmic Background Explorer (COBE), which was limited to a seven-degree angular resolution.

One reason for the improvement is that MAP employs two microwave telescopes, placed back-to-back, to focus the incoming radiation. The signals from the telescopes feed into 10 "differencing assemblies" that analyze five frequency bands in the CMB spectrum. But rather than measure the absolute temperature of the radiation, each assembly records the temperature difference between the signals from the two telescopes. Because the probe rotates, spinning once every two minutes and precessing once every hour, the differencing assemblies compare the temperature at each point in the sky with 1,000 other points, producing an interlocking set of data. The strategy is analogous

DON DIXON (*illustrations*); NASA (*photograph*)





MAP'S OBSERVATION POST is near the L2 Lagrange point, which lies on the sun-Earth line about 1.5 million kilometers beyond our planet. The probe moves around the L2 point while orbiting the sun at the same rate Earth does. This orbit ensures that MAP's telescopes will always have an unobstructed view of deep space.

MAP IS LAUNCHED from the Kennedy Space Center/Cape Canaveral Air Force Station.

to measuring the relative heights of bumps on a high plateau rather than recording each bump's elevation above sea level.

This method cancels out errors resulting from slight changes in the temperature of the spacecraft itself. The overall calibration of the data is done through a continuous measurement of the CMB dipole moment, the change in radiation temperature caused by Earth's motion through the cosmos. The guiding principle of MAP's design is to eliminate any spurious signals that might contaminate its measurements of the CMB. All indications are that MAP will begin returning high-quality results in January 2003, as scheduled. The cosmic map it will produce, of unprecedented fidelity, will be MAP's legacy for cosmology. SA

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