NASA 927, a converted Korean War-era bomber, spent four decades broiling beneath the unrelenting Sun at a boneyard in Tucson. Since being brought out of its desert retirement in 2013, the WB-57F Canberra has studied Earth’s atmosphere and supported military operations. On August 21, though, it will get reacquainted with the Sun during the total solar eclipse. It will speed through the Sun’s shadow for four minutes, pointing both visible and infrared instruments at the Sun’s corona, its hot but faint outer atmosphere. The aircraft will share the duty with NASA 926, a second Canberra, which will log an additional four minutes in the shadow.

“We want all the totality we can get,” says Amir Caspi, the project’s leader and a research scientist at the Southwest Research Institute in Boulder, Colorado. “On the ground, the maximum is about 2 minutes, 40 seconds. If you chase the shadow from the air, you can extend that time. As the shadow passes by the first plane, it starts passing over the next one, so we get about eight minutes of observations. It’s something we’re pretty excited about.”

By Damond Benningfield
The twin Canberras won’t be the only scientific eyes on the eclipse, though. Astronomers around the country will load their telescopes on trailers, trucks, and other airplanes to catch this rarest of all major astronomical events. The continental United States hasn’t experienced a total solar eclipse since 1979, and the last eclipse to cross such an extensive swath of the country took place in 1918, near the end of World War I.

“The Sun is different every time you look at it,” says Jay Pasachoff, an astronomer at Williams College in Maryland and a veteran of more than 30 total solar eclipses. “If you were a heart surgeon, and you could see inside a heart for only a couple of minutes, on the other side of the world, you’d certainly go see it. And if you could see it for another two minutes 18 months later somewhere else, you’d do that, too. Things change on the Sun, and we want to see that.”

That’s because, despite centuries of intensive study of our star, many questions about its workings remain unanswered. “Because it’s so close, we have a huge amount of information about the Sun,” says C. Alex Young, a solar astronomer and an associate director of NASA’s Heliophysics Science Division. “We see that it’s incredibly complicated — it’s an amazingly complex system of particles, magnetic fields, plasma. So there’s still a lot to learn about it, from how its dynamo works to how you get solar flares and coronal mass ejections.”

Flares (explosions that are the equivalent of millions of H-bombs) and coronal mass ejections (CMEs, which are clouds of billions of tons of charged particles) are particularly important because they can trigger big problems on Earth. They
produce torrents of electromagnetic radiation and electrically charged particles that can knock out power grids, damage or destroy orbiting satellites, disrupt radio communications and airline schedules, and interfere with the Global Positioning System.

“The most important thing about the Sun is the societal impact of space weather,” says Paul Bryans, a project scientist at the National Center for Atmospheric Research in Boulder. “If these eruptive bursts of energy on the Sun are directed toward Earth, they can have a big effect — especially now, when we use so many GPS devices. They can mess up a lot of things. We’d like to predict when they’re going to happen, but we’re not very good at it yet.”

One of the keys to understanding these eruptions is the corona, the Sun’s hot but thin outer atmosphere, which extends millions of miles into space — the region where flares erupt and CMEs are accelerated to millions of miles per hour. While the Sun’s surface sizzles at about 10,000 degrees Fahrenheit (5,500 C), the corona reaches temperatures of more than a million degrees or higher. We can’t see the corona, though, because it’s just one trillionth the density of the gas at the Sun’s visible surface, so it’s only about one millionth the brightness of the solar disk.

Astronomers still don’t fully understand why the corona is so much hotter than the Sun’s surface, though. The heat can’t come from the surface itself because nothing can warm another object beyond its own temperature (a 350-degree oven can’t heat a pizza to a thousand degrees, for example).

Solar physicists have developed two competing theories to explain the discrepancy: microflares and waves.

Solar flares erupt when the Sun’s magnetic field lines get tangled, then snap, like a twisted rubber band that suddenly breaks. Microflares may be much smaller versions of these eruptions, with each eruption transferring energy from the magnetic field to the corona. “The theory is that these happen on small scales all the time, all through the corona,” says Caspi. “They’re so small, numerous, and constant that we can’t see individual events — it’s a roiling broil.”

The other theory posits that energy is transferred to the corona through waves in the magnetic field. “The waves can be converted from one mode to another, and when that happens, it deposits its heat,” says Caspi. “It’s like putting food in a microwave oven. The microwaves don’t heat the food directly — they excite water molecules in the food, and the vibrations of those molecules heat the food.”

Detailed observations of the corona should allow astronomers to choose between the two heating mechanisms. Yet studying the corona through the full glare of the Sun is like trying to study the light from a firefly silhouetted against a searchlight. Astronomers can create artificial eclipses by blocking out the Sun with a small disk inside a telescope. From Earth’s surface, though, the atmosphere scatters so much sunlight that it’s difficult to see the corona in any detail. And from space, one can’t heat a pizza to a thousand degrees, for example.

One of the keys to understanding these eruptions is the corona, the Sun’s hot but thin outer atmosphere, which extends millions of miles into space — the region where flares erupt and CMEs are accelerated to millions of miles per hour.

Astronomers still don’t fully understand why the corona is so much hotter than the Sun’s surface, though. The heat can’t come from the surface itself because nothing can warm another object beyond its own temperature (a 350-degree oven can’t heat a pizza to a thousand degrees, for example).

Solar physicists have developed two competing theories to explain the discrepancy: microflares and waves.

Solar flares erupt when the Sun’s magnetic field lines get tangled, then snap, like a twisted rubber band that suddenly breaks. Microflares may be much smaller versions of these eruptions, with each eruption transferring energy from the magnetic field to the corona. “The theory is that these happen on small scales all the time, all through the corona,” says Caspi. “They’re so small, numerous, and constant that we can’t see individual events — it’s a roiling broil.”

The other theory posits that energy is transferred to the corona through waves in the magnetic field. “The waves can be converted from one mode to another, and when that happens, it deposits its heat,” says Caspi. “It’s like putting food in a microwave oven. The microwaves don’t heat the food directly — they excite water molecules in the food, and the vibrations of those molecules heat the food.”

Detailed observations of the corona should allow astronomers to choose between the two heating mechanisms. Yet studying the corona through the full glare of the Sun is like trying to study the light from a firefly silhouetted against a searchlight. Astronomers can create artificial eclipses by blocking out the Sun with a small disk inside a telescope. From Earth’s surface, though, the atmosphere scatters so much sunlight that it’s difficult to see the corona in any detail. And from space, one can’t heat a pizza to a thousand degrees, for example.

Solar physicists have developed two competing theories to explain the discrepancy: microflares and waves.

Solar flares erupt when the Sun’s magnetic field lines get tangled, then snap, like a twisted rubber band that suddenly breaks. Microflares may be much smaller versions of these eruptions, with each eruption transferring energy from the magnetic field to the corona. “The theory is that these happen on small scales all the time, all through the corona,” says Caspi. “They’re so small, numerous, and constant that we can’t see individual events — it’s a roiling broil.”

The other theory posits that energy is transferred to the corona through waves in the magnetic field. “The waves can be converted from one mode to another, and when that happens, it deposits its heat,” says Caspi. “It’s like putting food in a microwave oven. The microwaves don’t heat the food directly — they excite water molecules in the food, and the vibrations of those molecules heat the food.”

Detailed observations of the corona should allow astronomers to choose between the two heating mechanisms. Yet studying the corona through the full glare of the Sun is like trying to study the light from a firefly silhouetted against a searchlight. Astronomers can create artificial eclipses by blocking out the Sun with a small disk inside a telescope. From Earth’s surface, though, the atmosphere scatters so much sunlight that it’s difficult to see the corona in any detail. And from space, one can’t heat a pizza to a thousand degrees, for example.

Solar physicists have developed two competing theories to explain the discrepancy: microflares and waves.

Solar flares erupt when the Sun’s magnetic field lines get tangled, then snap, like a twisted rubber band that suddenly breaks. Microflares may be much smaller versions of these eruptions, with each eruption transferring energy from the magnetic field to the corona. “The theory is that these happen on small scales all the time, all through the corona,” says Caspi. “They’re so small, numerous, and constant that we can’t see individual events — it’s a roiling broil.”

The other theory posits that energy is transferred to the corona through waves in the magnetic field. “The waves can be converted from one mode to another, and when that happens, it deposits its heat,” says Caspi. “It’s like putting food in a microwave oven. The microwaves don’t heat the food directly — they excite water molecules in the food, and the vibrations of those molecules heat the food.”

Detailed observations of the corona should allow astronomers to choose between the two heating mechanisms. Yet studying the corona through the full glare of the Sun is like trying to study the light from a firefly silhouetted against a searchlight. Astronomers can create artificial eclipses by blocking out the Sun with a small disk inside a telescope. From Earth’s surface, though, the atmosphere scatters so much sunlight that it’s difficult to see the corona in any detail. And from space, one can’t heat a pizza to a thousand degrees, for example.

Solar physicists have developed two competing theories to explain the discrepancy: microflares and waves.

Solar flares erupt when the Sun’s magnetic field lines get tangled, then snap, like a twisted rubber band that suddenly breaks. Microflares may be much smaller versions of these eruptions, with each eruption transferring energy from the magnetic field to the corona. “The theory is that these happen on small scales all the time, all through the corona,” says Caspi. “They’re so small, numerous, and constant that we can’t see individual events — it’s a roiling broil.”

The other theory posits that energy is transferred to the corona through waves in the magnetic field. “The waves can be converted from one mode to another, and when that happens, it deposits its heat,” says Caspi. “It’s like putting food in a microwave oven. The microwaves don’t heat the food directly — they excite water molecules in the food, and the vibrations of those molecules heat the food.”

Detailed observations of the corona should allow astronomers to choose between the two heating mechanisms. Yet studying the corona through the full glare of the Sun is like trying to study the light from a firefly silhouetted against a searchlight. Astronomers can create artificial eclipses by blocking out the Sun with a small disk inside a telescope. From Earth’s surface, though, the atmosphere scatters so much sunlight that it’s difficult to see the corona in any detail. And from space, one can’t heat a pizza to a thousand degrees, for example.

Solar physicists have developed two competing theories to explain the discrepancy: microflares and waves.

Solar flares erupt when the Sun’s magnetic field lines get tangled, then snap, like a twisted rubber band that suddenly breaks. Microflares may be much smaller versions of these eruptions, with each eruption transferring energy from the magnetic field to the corona. “The theory is that these happen on small scales all the time, all through the corona,” says Caspi. “They’re so small, numerous, and constant that we can’t see individual events — it’s a roiling broil.”

The other theory posits that energy is transferred to the corona through waves in the magnetic field. “The waves can be converted from one mode to another, and when that happens, it deposits its heat,” says Caspi. “It’s like putting food in a microwave oven. The microwaves don’t heat the food directly — they excite water molecules in the food, and the vibrations of those molecules heat the food.”

Detailed observations of the corona should allow astronomers to choose between the two heating mechanisms. Yet studying the corona through the full glare of the Sun is like trying to study the light from a firefly silhouetted against a searchlight. Astronomers can create artificial eclipses by blocking out the Sun with a small disk inside a telescope. From Earth’s surface, though, the atmosphere scatters so much sunlight that it’s difficult to see the corona in any detail. And from space, one can’t heat a pizza to a thousand degrees, for example.
Wyoming, Bryans and his team will measure the corona's infrared spectrum with an instrument that was designed to study Earth's atmosphere from an aircraft. “This wavelength range of the solar corona has never been systematically covered before,” Bryans says. The spectrum in that range “is sensitive to the magnetic field of the Sun’s atmosphere, so if we can measure the spectrum, we can infer the magnetic field.”

Colleagues will study the eclipse from a Gulfstream jet flying over Kentucky, where the eclipse path will be near its maximum width of about 70 miles (110 km). Using special cameras based on the design of the eyes of a preying mantis, the astronomers will measure the polarization of the corona. The light is polarized by the Sun’s magnetic field, so the observations will provide a detailed map of the field as its lines of force infiltrate the corona. A second instrument will provide infrared spectra of small regions of the corona, helping to map its structure.

The WB-57Fs, part of a three-aircraft fleet (the only Canberras still flying) at Ellington Field, near Johnson Space Center in Texas, will deploy to southern Illinois with a suite of instruments, including an infrared system similar to the one on the Gulfstream (the two teams are working together, and will share their data).

In addition to providing extra time for viewing the corona, the aircraft offer other eclipse-watching benefits, says Caspi (who, for safety reasons, probably will monitor the experiment from the ground, not the cockpit). “They’ll get above the clouds, so we won’t be rained out. They’ll be at 50,000 feet, which is above so much of the atmosphere that the seeing [the clarity and stability of the view] will be incredibly good. And we'll be above most of the atmospheric water vapor, which absorbs infrared light.”

A telescopic camera system designed to watch space shuttle launches for falling debris will track the Sun throughout the eclipse. The cameras will record the corona at 30 frames per second in high definition, providing high-speed views unlike anything else ever recorded, Caspi says. “We hope to see ‘wiggles’ in the corona on timescales that we’ve never seen before. If you do that from the ground, you wouldn’t know if the wiggles were waves in the corona or turbulence in the atmosphere.” Detecting such high-speed wiggles would favor the wave theory of coronal heating.

Another instrument will use a filter to isolate the light from ionized iron atoms (similar to the ground-based Hawaii observations), tracing the lines of magnetic force, which often form loops that are far bigger than Earth.

As a bonus, the two aircraft will measure the chemical composition of the surface of Mercury, which will appear near the Sun in the darkened sky, and look for Vulcanoids, which are possible small asteroids inside Mercury’s orbit.

While the scientists are eager to peruse these and many other observations, all of them — especially the first-timers — also are eager to cast their own eyes on a sight that has amazed, astounded, and terrified the human race since the beginning. “I’m hoping that all I have to do is push a button and let the instrument do its thing,” says Caspi, “because I’m probably more excited about seeing it than I am the science.”

A view of the corona during a 1991 eclipse. A geyser of hot gas, known as a prominence, erupts at right.