Astronomers find key evidence supporting theory of quasars

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The office that astronomer Lei Hao shares with her fellow research associates on the first floor of the Space Sciences Building at Cornell University is tidy and organized. But Hao has been thinking a lot lately about dust.
Actually, she's recently found a great deal of it. And she's thrilled.

The dust in question is between 0.88 billion and 2.4 billion light years away from Hao's office, in galaxies scientists classify as active galactic nuclei (AGNs). By confirming that the dust exists, Hao and her team of researchers from Cornell and several other institutions have given new weight to a popular, but not universally accepted, theory of AGNs. Their new evidence is published in the June 1 issue of *Astrophysical Journal Letters* (Vol. 625, pp. L75-L78).

Since the early 1980s, the most widely accepted model of AGNs, called the unified theory, involves a basic structure: a black hole at the center, an accretion disc (a round, flat sheet of gas) around it and a doughnut-shaped ring of dusty gas, called a torus, around the accretion disc. Jets of matter are propelled out from the center perpendicular to the plane of the accretion disc.

The model holds that all AGNs share the same fundamental characteristics, but it allows for different radiation patterns with the premise that how an AGN looks depends on the perspective of the observer. An AGN viewed face-on, classified as type 1, will show features from its central region; an AGN viewed from the side (type 2) will have those features obscured by the dusty torus. AGNs include quasars, which look like stars in optical telescopes but emit massive amounts of radiation; Seyfert galaxies, low-energy counterparts of quasars; and blazars, which are AGNs viewed pole-on and which show rapid variations in radiation output over short intervals.

From an observational standpoint, the model has been largely successful. But for years, a key piece of evidence has been missing.

Astronomers can determine the composition and temperature of extragalactic material by analyzing the way radiation passing through it is distributed along an infrared spectrum. When radiation passes through silicate dust (a fine, sandy substance common in interstellar dust), the dust grains absorb it at specific wavelengths and leave dips in the infrared spectrum around 10 and 18 microns.

When scientists observe type 2 AGNs, they recognize the silicate component of the dusty torus by the telltale 10- and 18-micron absorption dips. But in order for the unified theory to be correct, scientists looking down from the top or up from below a type 1 AGN would expect to see excess radiation from the silicate dust at 10 and 18 microns. They didn't -- and that inconsistency led some to wonder if the theory was flawed.

Hao's observations of silicate emission bands from type 1 AGNs are likely to quell those doubts.

In their paper, Hao and her colleagues describe five quasars (type 1 AGNs) for which clear bumps in infrared emissions have been discovered at 10 and 18 microns. The measurements were taken by the Spitzer Space Telescope's infrared spectrograph, which was developed by Cornell professor of astronomy James Houck and is one of three instruments on the orbiting space telescope.

"People have been expecting this feature for a long time," says Hao. And it has always been there, she adds, but nobody had recognized it until now -- partly because the Spitzer's technology is more sensitive than earlier versions and partly because other instruments didn't include a wide enough spectral range to catch the 10 and 18 micron features.

Finding evidence of dust may not seem important to non-astronomer types, Hao allows. But she's not letting that dampen her enthusiasm. "For us it's quite dramatic," she says. And by comparing the two emission bumps, scientists can begin to learn even more about the AGNs. "The relative ratio between the two features can give some information on the inner temperature of the dusty torus," she says. Those calculations are just preliminary, but finding long-sought evidence of the dust in the first place is enough to make Hao grin. "You can see," she says, "that we verified the unification model."

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