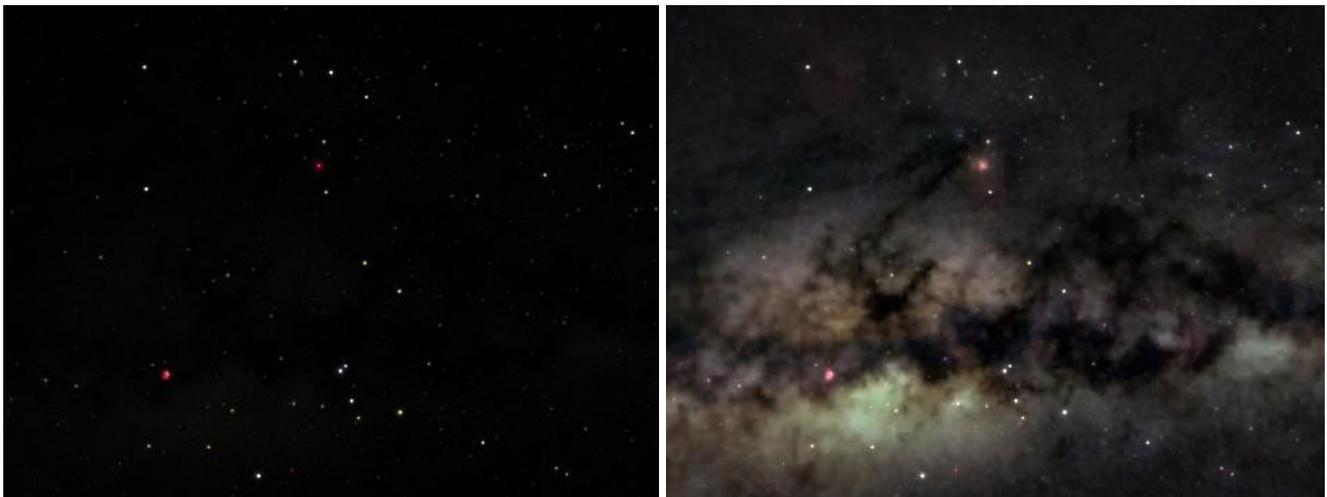
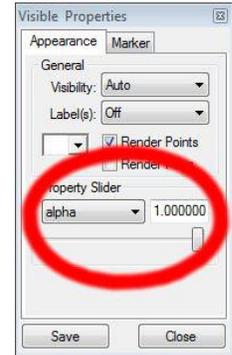


Storytelling with Uniview #07: Touring the Far-Infrared Sky

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Let's talk about the Milky Way—not the three-dimensional volumetric model in Uniview—but the visible band that in real life, you would have to find a secluded, dark, clear site to see. In Uniview, you do not have to find a dark spot; you just have to turn up the brightness of the background Milky Way layer! From the Object Tree, select **Milky Way**→**All-Sky Surveys**→**Visible**. Then in the Properties window, set the Property Slider to the *alpha* parameter. It should by default be at 0.25 (below left image). Slide it to the right (to a maximum value of 1.00) and you will see the sky background and the band of the Milky Way brighten considerably (below right image). To make it even easier to see, turn off the planets and the rest of the Solar System.



The band of the Milky Way is the disk of our home Galaxy. Since the Sun is in the middle of the disk, halfway out from the center to the edge (see *Storytelling with Uniview #2*), we see the Galactic disk as a band of light that encircles us in the sky. However the disk is not uniform in brightness. It looks rather dark and is very patchy—again this is much more apparent when the *alpha* property is turned up. These dark areas are showing not the absence of stars in the Galactic disk, but the presence of obscuring material that keeps us from observing the light from background stars.

These are the molecular clouds in the interstellar medium, made up mostly of molecular hydrogen (H_2) gas along with helium, and a smattering of other trace molecules. Although the gas can scatter and absorb light passing through the clouds, most of the extinction of light is due to the dust grains suspended within the clouds. The word “dust” is somewhat of a misnomer, since the public might think these to be similar to the dust bunnies that we see accumulating under our living room sofas. But the dust in interstellar space is far tinier: at the low end, they may contain tens of atoms; at the high end, tens of billions of atoms which makes them less massive than a typical bacterium. Dust grains have sizes typically from tens to a few hundred nanometers in diameter, the upper range of which is

about the median diameter of the particles in cigarette smoke.

Interstellar dust preferentially scatters short wavelength (bluer) light, while longer wavelength (redder) light has a greater probability of passing through. But if the density of gas and the embedded dust is high enough (or if the cloud containing the dust is large enough, meaning the photons have to traverse a greater distance), even the redder photons from starlight are scattered almost completely away. For a thick enough cloud—like those we see in the disk of our Milky Way—practically all of the light from a background star can be extinguished away, and hence the appearance of the dark nebulae.

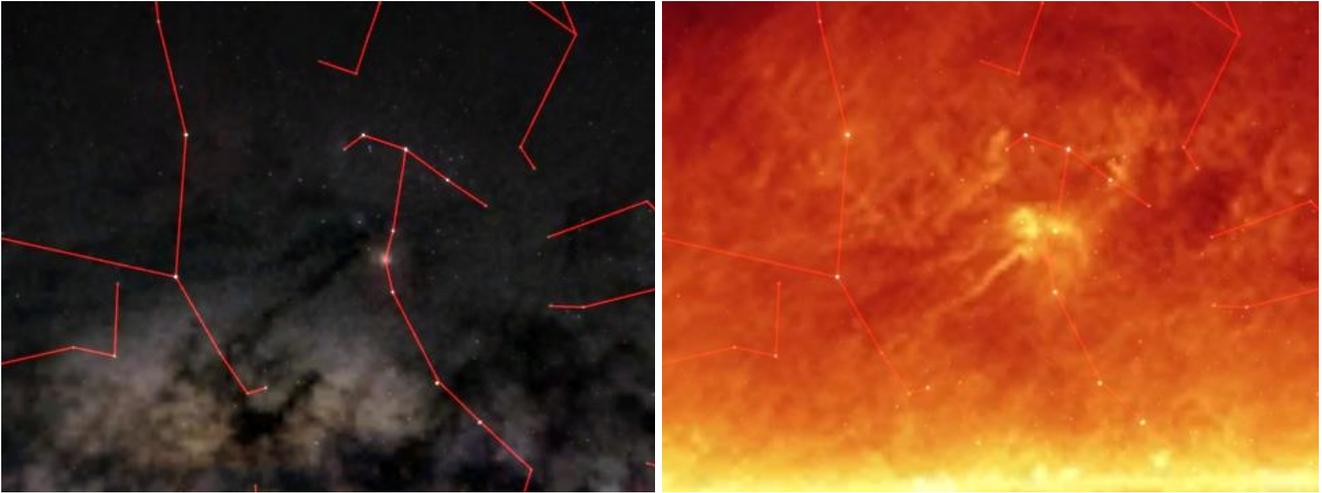
The interiors of these molecular clouds have temperatures of 10-20 degrees Kelvin, meaning that they are too cold to emit light at visible wavelengths. However they are still warm enough that they glow faintly in the mid- and far-infrared wavelengths, which are typically defined by astronomers to be in the wavelength regime, respectively, of 3-15 microns and 20-1000 microns. If we turn on one of the all sky surveys mapped in long infrared wavelengths, we will see the glow of interstellar dust in the sky.

One set of infrared datasets available in Uniview is from IRAS (Infrared Astronomical Satellite), which was launched by NASA in 1983. It observed with a relatively small collector—a mirror only 20 cm across. IRAS mapped the sky for 10 months at 12, 25, 60, and 100 microns before its liquid helium coolant ran out. (As a result, you can see black wedges in these maps, parts of the sky that the satellite missed when its detector warmed up.)

The dataset [Milky Way→All-Sky Surveys→IRAS Composite](#) is a mix of different wavelengths which muddles some of the details. As a result I like to turn on instead [Milky Way→All-Sky Surveys→IRAS Far Infrared](#), which shows only the 100 micron data. With this toggled on and its *alpha* value set to a high value, the Uniview screen is filled with glows and filamentary structures in colors ranging from yellow to orange to deep red. To be completely accurate, you may wish to turn off the point stars, which emit very little radiation at mid- and far-infrared wavelengths. However since the far-infrared features tend not to look like anything else you may be familiar with in the night sky, you may want to have the constellation lines on to remind yourself where you are looking.

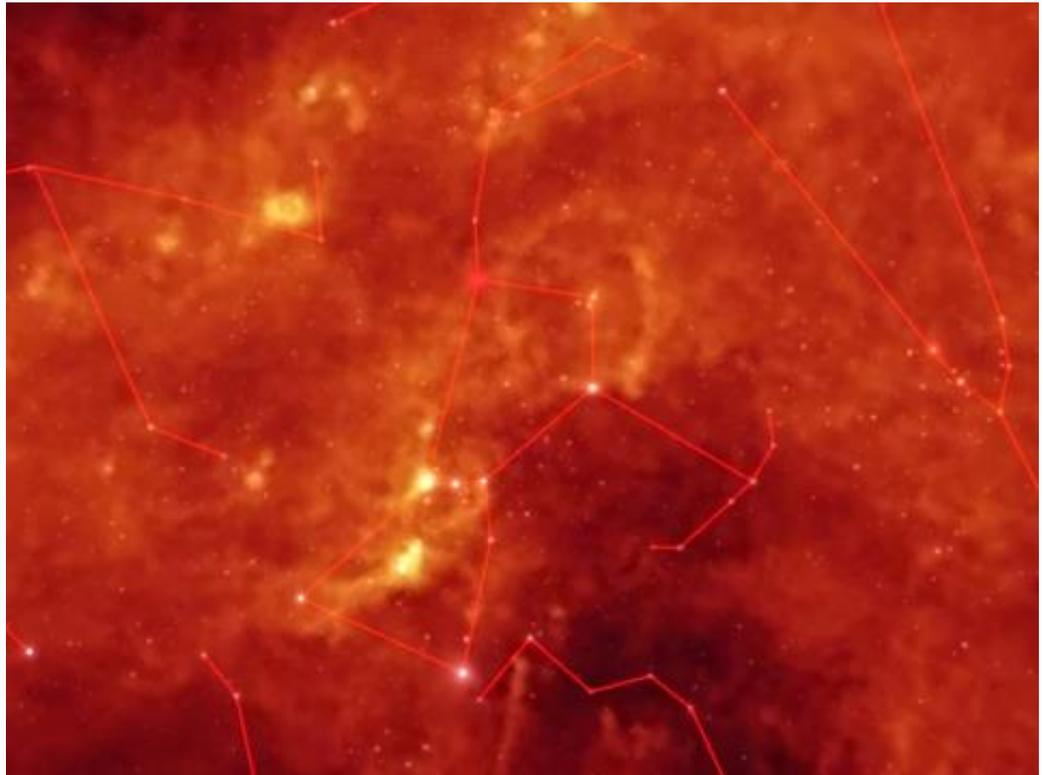
First the band of the Milky Way is in bright yellow. Hence we are seeing the glow from lots of dust embedded in the thick molecular clouds that mark the spiral arms in spiral galaxies. The glow is also brightest toward the Galactic Center, in the constellation of Sagittarius. (The exact location of the Galactic Center is just past the tip of the spout of the teapot in Sagittarius.)

Although it is difficult to see correspondence between the far-infrared and visible light features, one place where there are clear parallels is in Ophiuchus and Scorpio. The Ophiuchus dark clouds (just to the left of the star Antares in Scorpio in the below pictures), have features that are similar as dark nebulae in the visible light image on the left, as well as the far-infrared glow in the picture on the right. These clouds are only about 130 parsecs (420 light years) away, and contain some of the closest star forming regions to the Sun. A cluster of somewhat older stars (of which Antares is a member) formed in the last 15 million years and is also centered in this region.



Another star forming region is in the constellation of Orion. In visible light, the Orion Nebula is visible in Orion's Sword, and contains the closest O stars to the Sun (about 400 parsecs or 1300 light years away). Many younger lower mass stars are found in the cluster around the Nebula, including protostars surrounded by proplyds. In the far-infrared, two large molecular clouds show up as bright yellow clumps: the Orion A cloud located in the Sword of Orion, and the Orion B cloud near the belt star Alnitak. These clouds each have masses about 100,000 times that of the Sun. (The most famous feature in the Orion B cloud is the Horsehead Nebula.)

The "head" of Orion is marked by the O-star lambda Orionis. In the far-infrared, you can see a ring of dust emission that surrounds the small cluster that includes lambda Orionis and several B-stars. It is likely that the winds and radiation from the massive stars in this cluster have simultaneously disrupted and pushed the surrounding gas clouds into the remarkable circular shape.



Although most of the far-infrared emission is near the Galactic plane, there are also faint wispy filaments that extend far above and below that plane. Because of their appearance, they are called

“cirrus” clouds. Many appear to be local and close (within a few hundred light years) to the Sun. Others are further away, and have high velocities, suggesting they originate outside the Galaxy. However it is not clear whether these consist of gas expelled out of the Milky Way, and are falling back into the plane, or whether they are actually primordial gas from interstellar space falling to our Galaxy for the first time.

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The content in this column can be tied to other interactives in Space Odyssey. The [Milky Way→All-Sky Surveys→IRAS Far Infrared](#) map is based on collected photons with much longer wavelengths than those observed at the infrared experiment table and the IR camera. Yet there are common messages that apply to both the hands-on and virtual interactives. First, electromagnetic radiation comes in different wavelengths, and our eyes are sensitive to only a small part of the spectrum. And next, probing in the infrared in astronomy allows us to study matter that is invisible to our eyes, but which in the case of dark nebulae full of interstellar dust, actively *blocks* light at visible wavelengths!

Reference

Henbest, N., & Couper, H. 1994, *The Guide to the Galaxy*, New York, NY: University of Cambridge.