The Wide-field Infrared Survey Experiment (WISE) recently took its first photo of a test field in the constellation Carina to check out its instruments.

WISE is based on a 40-cm (16-inch) telescope designed to detect radiation at four wavelengths: 3.4, 4.6, 12 and 22 microns. The telescope is kept cold using solid hydrogen at a temperature of -438 F (12 Kelvin), and will be able to function for about 10 months in space until the hydrogen evaporates. In this time, WISE will take over a million pictures of the whole sky, revealing hundreds of millions of stars, galaxies, asteroids and other objects that shine brightly in the infrared spectrum.

The image to the left, measures 47arcminutes x 23 arcminutes (60 arcmin equals one angular degree). It is a portion of the WISE 'First Light' image near the bright star V482 Carinae seen to the right. The full moon would cover a square 30 arcminutes on a side.

Astronomers not only study individual stars in a field like this, but also count the stars in each brightness interval in order to mathematically model how stars are distributed in the Milky Way. Such models help us understand the shape and history of

Problem 1 - The bright star seen in this field is V482 Carinae. It has a stellar brightness of +6.0. If the area of this field has dimensions of 0.8 degrees x 0.4 degrees, how many stars as bright as V482 are present, on average, A) per square degree of the sky? B) Across the entire sky if its area is 41,253 deg^2?

Problem 2 - The function A(m) represents the total number of stars per deg^2 counted in the stellar brightness (called 'magnitude') bin from m-1/2 to m+1/2 centered on m. The function has the units of 'stars/deg^2/magnitude'. If $A(m)= 3m^{+3.5}$, how many stars would be counted, on average, in: A) a field that is the size of the full moon, (area = 0.25 deg^2) at a magnitude of m=+12.0? B) the same field and with a magnitude bin +2.3 in size?

Problem 3 - Near the wavelength of 3.4 microns being explored by WISE, an astronomer estimated from the Spitzer Infrared Observatory 'First Light' survey that at this wavelength, $A(m) = 2.4 \times 10^{-6}\ m^{+7.4}$ stars/magnitude/deg^2. Suppose that the faintest star detectable by WISE has a magnitude of m = +15. Using the method of integration, how many total number of stars would WISE be able to detect in a field equal to the WISE survey area of 0.64 deg^2, and that are fainter than V482 Carina?

Problem 1 - The bright star seen in this field is V482 Carinae. It has a stellar brightness of +6.0. If the area of this field has dimensions of 0.8 degrees x 0.4 degrees, how many stars as bright as V482 are present, on average, A) per square degree of the sky? B) Across the entire sky if its area is 41,253 deg^2?

Answer: A) The area of the field is 0.8 x 0.4 = 0.32 deg^2 and since there is only one star with a brightness of +6 in this area, A(+6.0) = 1 star / 0.32 deg^2 = **3.1 stars/deg^2**. B) Across the entire sky, N = 3.1 stars/deg^2 x 41,253 deg^2 gives **N = 128,000 stars**.

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Answer: A) First A(12.0) = 3 $(12)^{+3.5}$ = 18,000 stars/deg^2/magnitude. Then for an area of 0.25 deg^2 we have N(m) = A(m) x (0.25 deg^2) = 18,000 x 0.25 = **4,500 stars/magnitude**.
B) The bin width is now 2.3, so N = 4,500 stars/magnitude x (2.3 magnitudes) = **10,000 stars**.

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Answer: The integral to perform is:

$$N = \int_{+6}^{+15} 2.4x10^{-6} m^{+7.4} dm \quad \text{which yields:} \quad N = \frac{2.4x10^{-6}}{8.4}\left[(15)^{8.4} - (6)^{8.4}\right]$$

so N = 2,162 stars/deg^2.

Since the field in question has an area of 0.64 deg^2, the prediction is that there would be N = 2,164 stars/deg^2 x (0.64 deg^2) = 1,385 stars in an average star field of this size.

Note: The WISE satellite's First Light star field near V482 Carinae was close to the plane of the Milky Way, so the estimated 3,000 stars reportedly seen in its field is higher than what one may estimate from functions that model average numbers. Students may experiment with other choices for the power-law exponent, n, to see how sensitive the predictions are to the choice made, and the number of stars seen in the WISE image. Challenge them to find a means for excluding 0 < n < 3, or N > 8 as possibilities.