1. Your new advisor, Dr. Mayhem, is trying to find which of two galaxies hosts an AGN.

Dr. Mayhem points you to a paper by Donely et al. (2012), hands you table with data from the Spitzer telescope, and gives the helpful advice of "just figure it out".

The table has flux data for the four IRAC detectors:

IRAC channel	IRAC waveband [um]	flux [uJy] of galaxy A	flux [uJy] of galaxy B
CH1	3.6	13.58	17.49
CH2	4.5	18.15	17.05
CH3	5.8	27.77	12.62
CH4	8.0	49.23	10.83

a) What part of the electromagnetic spectrum does the Spitzer/IRAC detectors observe?

b) Why might an AGN have different fluxes in this wavelength range?

The paper states that a galaxy hosts an AGN if it meets the following criteria:

(i) $x = \log(f\_5.6um / f\_3.6um)$ $y = \log(f\_8.0um / f\_4.5um)$

(ii) $x > 0.08$ $y > 0.15$ $y > 1.21 x - 0.27$ $y < 1.21 x + 0.27$

(iii) $f\_4.5um > f\_3.6um$ $f\_5.8um > f\_4.5um$ $f\_8.0um > f\_5.8um$

**b) Qualitatively describe what each set of equations mean**

c) First, let's calculate the equations in (i). For both galaxies A and B, use the flux radios to get the CH3-CH1 color.

e) Now calculate the CH4-CH2 colors.

f) Next, lets see how the two galaxies relate to the equations in (ii). On the graph, sketch a point for both galaxies A and B. Use the results from question (b) and (c).
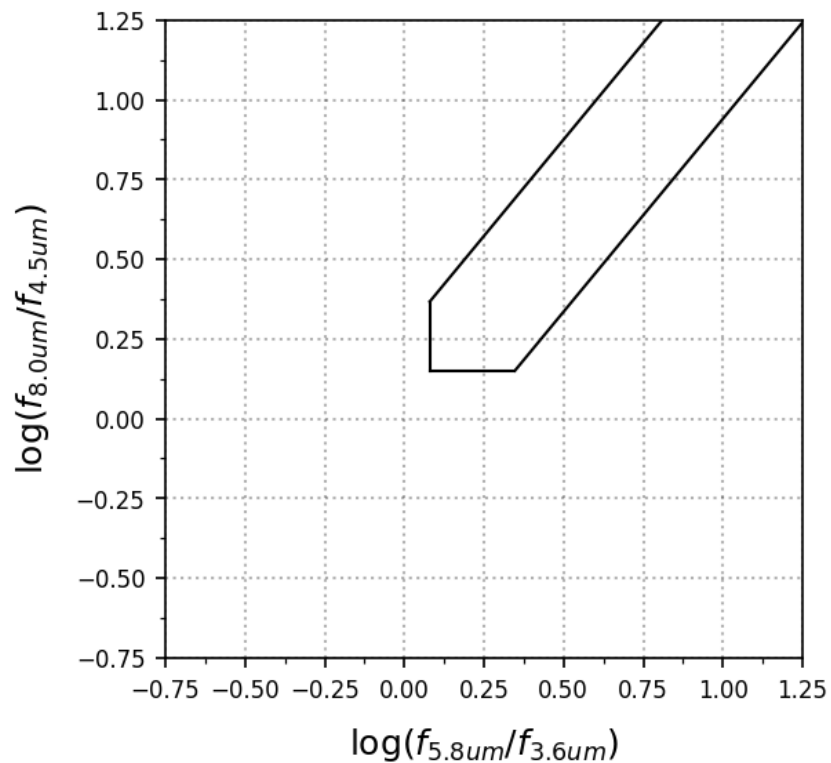
g) Lastly, let's investigate how the fluxes change, like equations (iii). Sketch a simple SED using the fluxes in the table.
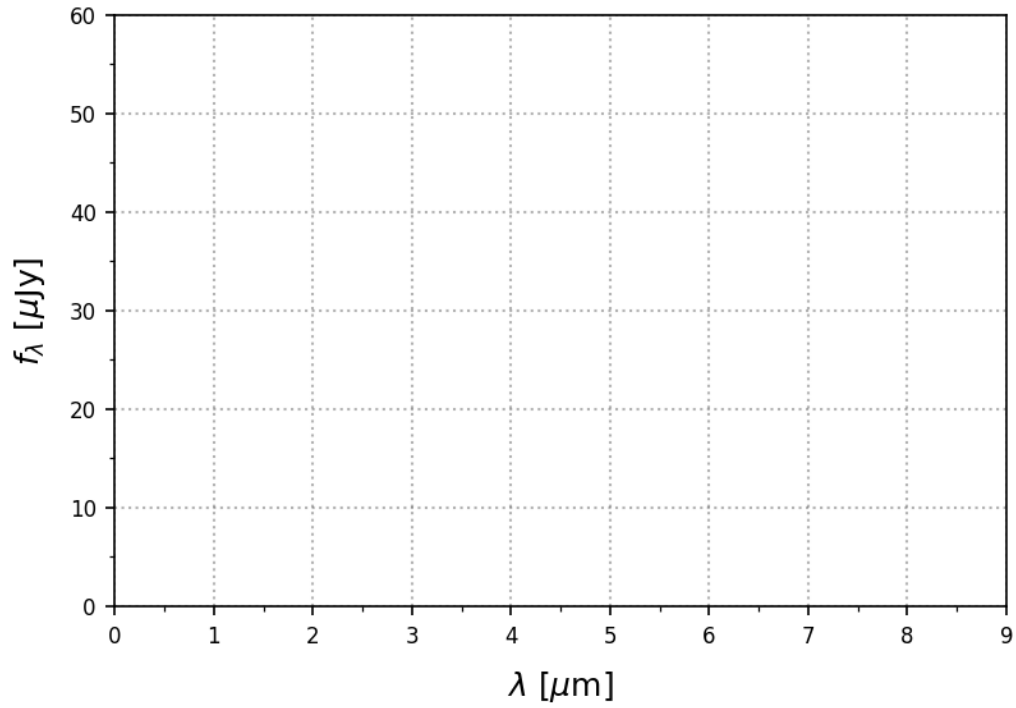
h) The time has come to face Dr. Mayhem! Which galaxy hosts an AGN? Why?

SOLUTIONS

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a) What part of the electromagnetic spectrum does the Spitzer/IRAC detectors observe?

Answer: Mid-infrared!

b) Why might an AGN have different fluxes in this wavelength range?

Answer: The central SMBH and accretion disk are surrounded by a torus of gas and dust. This cloud absorbs the high energy emission produced in the central engine and re-emits it in the infrared. This creates a continuous thermal blackbody spectrum. Star forming galaxies have weaker MIR emission here from dwarf stars and emission lines.

The paper states that a galaxy hosts an AGN if it meets the following criteria:

(i) $x = \log(f\_5.6um / f\_3.6um)$ $y = \log(f\_8.0um / f\_4.5um)$

(ii) $x > 0.08$ $y > 0.15$ $y > 1.21 x - 0.27$ $y < 1.21 x + 0.27$

(iii) $f\_4.5um > f\_3.6um$ $f\_5.8um > f\_4.5um$ $f\_8.0um > f\_5.8um$

b) Qualitatively describe what each set of equations mean

i) Answer: x and y are each flux ratios defining two colors

ii) Answer: This set of equations draws a wedge in color space. A galaxy is an AGN if it is inside the wedge.

iii) Answer: These inequalities state that the fluxes must always increase with wavelength to be an AGN.

c) First, let's calculate the equations in (i). For both galaxies A and B, use the flux radios to get the CH3-CH1 color.

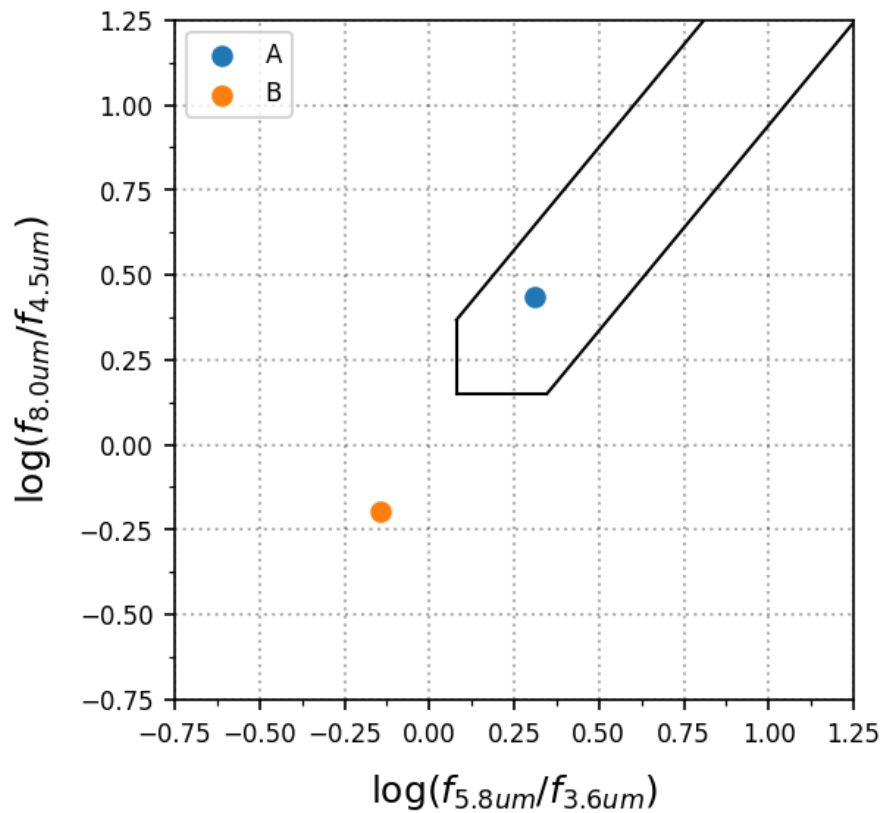*Answer:* $\quad x_A = \log\left(\frac{27.77}{13.58}\right) = 0.311$

$\quad\quad\quad\quad\quad x_B = \log\left(\frac{12.62}{17.49}\right) = -0.142$

e) Now calculate the CH4-CH2 colors.

Answer: $\quad y_A = \log\left(\frac{49.23}{18.15}\right) = 0.433$

$\quad\quad\quad\quad\quad y_B = \log\left(\frac{10.83}{17.05}\right) = -0.197$

f) Next, lets see how the two galaxies relate to the equations in (ii). On the graph, sketch a point for both galaxies A and B. Use the results from question (b) and (c).

g) Lastly, let's investigate how the fluxes change, like equations (iii). Sketch a simple SED using the fluxes in the table.
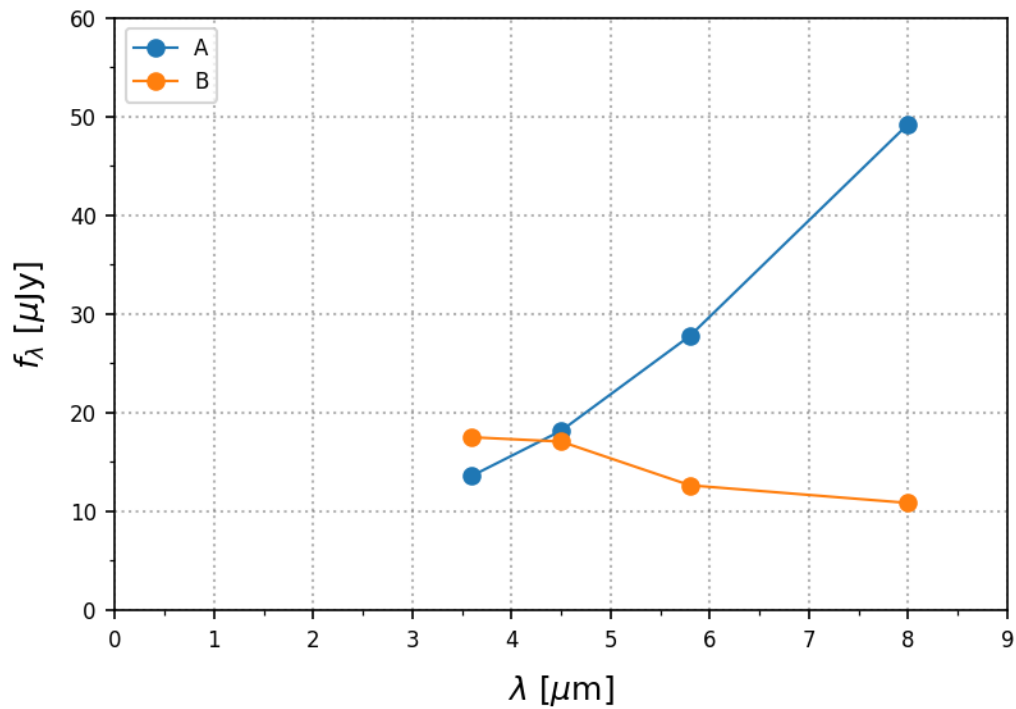
h) The time has come to face Dr. Mayhem! Which galaxy hosts an AGN? Why?

Answer: Galaxy A is an AGN! Its IRAC colors fall inside the wedge, and its fluxes increase with wavelength.