

# 9. Distances in open space

China

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# Statement of problem 9

How do astronomers measure distances between the planets of the Solar System, between the stars in our Galaxy, or between the galaxies? Determine the distance between the two space objects of your choice.

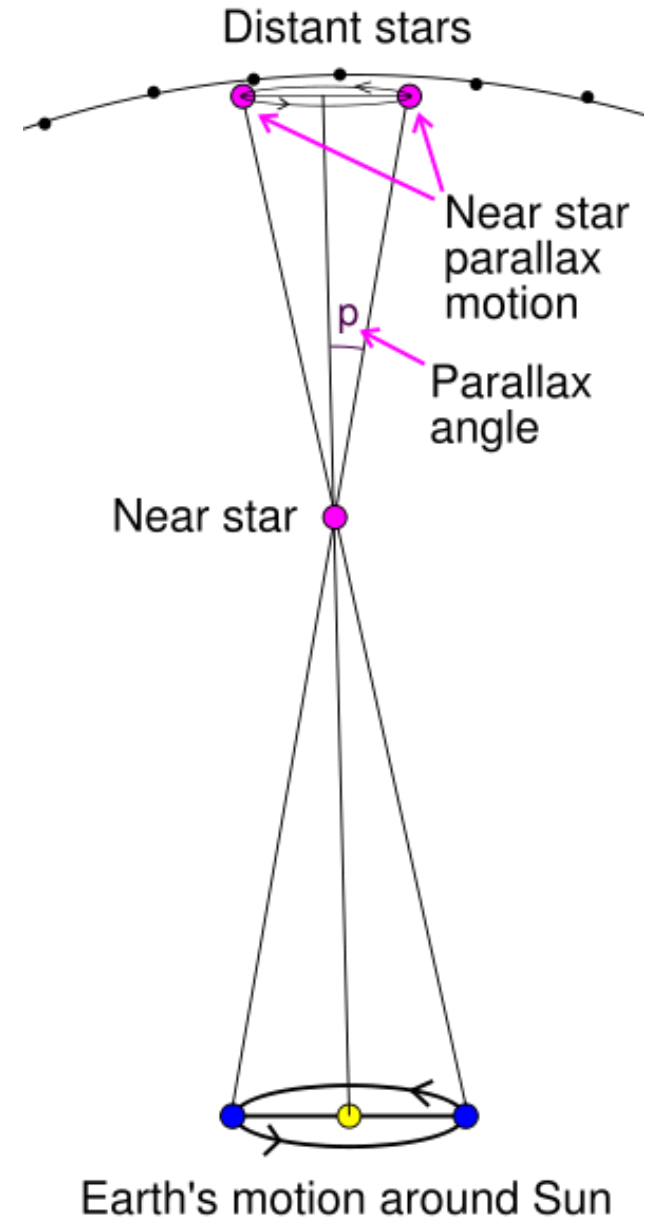
# between the planets of the Solar System

- orbit of planets
- Using laser(laser distance measuring)

# between the stars in our Galaxy

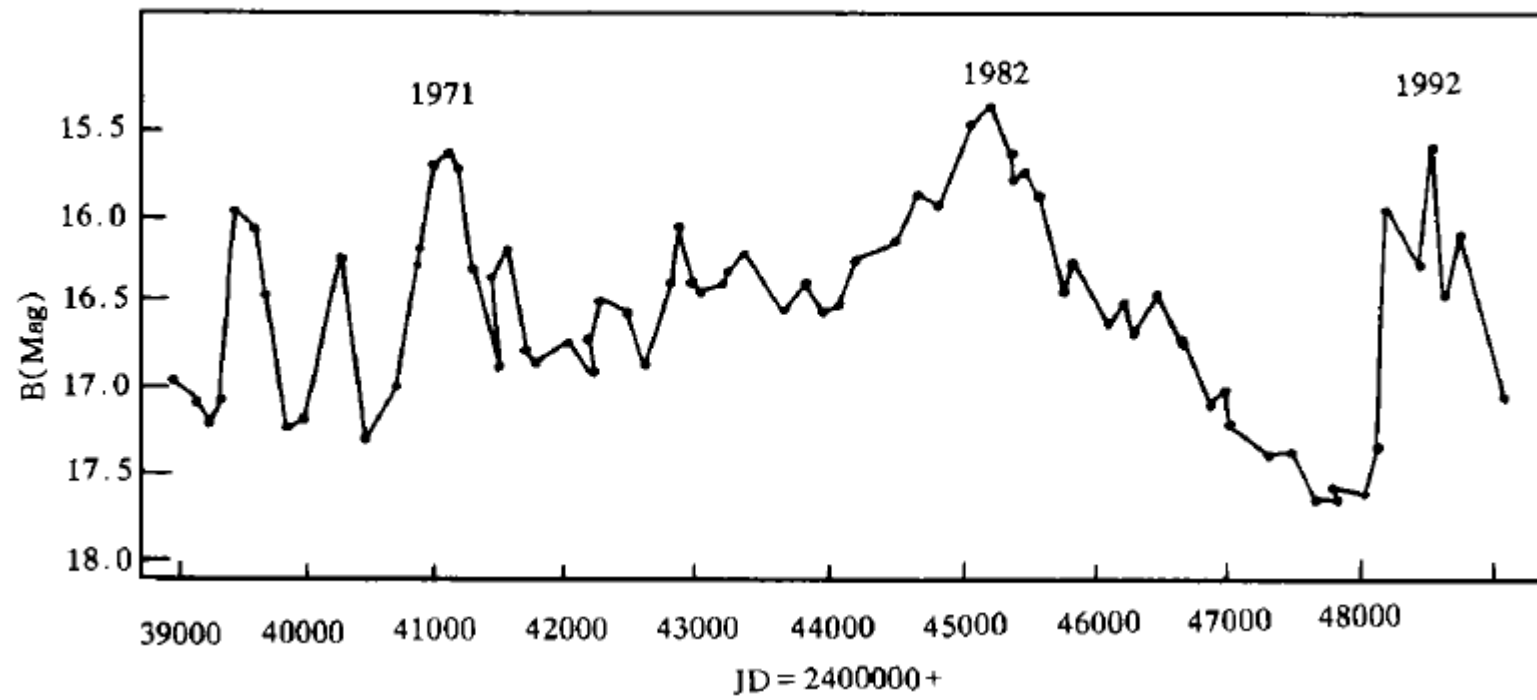
- Trigonometric Parallax
- period-luminosity relationship(Cepheid variable stars)

# Trigonometric Parallax



# Period-luminosity relationship(Cepheid variable stars)

- Empirical formula
  - population I star  $M = -1.80 - 1.741 \lg P$
  - population II star  $M = -0.35 - 1.74 \lg P$
  
- $M = m + 5 - 5 \log d$



The historical light curve for B band with values averaged over 100 days for 3C345

- $=0.5*0.5^4*(\text{COMBIN}(5,A3-1)-2*\text{COMBIN}(3,A3-2))+0.5*(0.75*\text{COMBIN}(2,A3-3)*0.5^2+0.25*\text{COMBIN}(2,A3-2)*0.5^2)$
- 25 7 3

- $=(49/2^{31})*(\text{COMBIN}(25,A4-1)-\text{COMBIN}(6,2)*\text{COMBIN}(19,A4-4))+ (15/2^{24})*(0.75*\text{COMBIN}(18,A4-4)+0.25*\text{COMBIN}(18,A4-3))$

- 5 3 2



# between the galaxies

- period-luminosity relationship(Cepheid variable stars)
- Redshifts in spectral lines

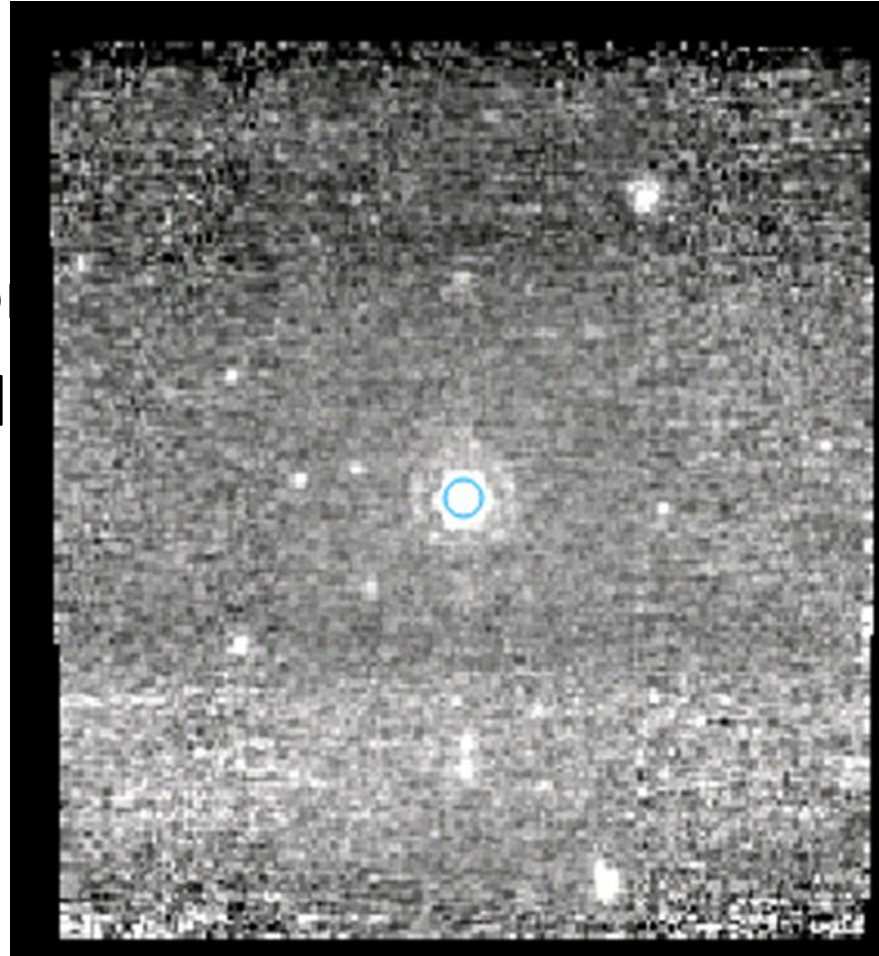
Determine the distance between the two space objects of your choice.

two space objects

The Sun and APM 08279+5255

# APM 08279+5255

- Quasar
- Lynx (constellation)
- One of the most l



se

# Theory

- The distance between the sun and APM 08279+5255 → The distance between the earth and APM 08279+5255
- Redshift of spectral line
  - Expansion of the space
  - Doppler effect
    - Hubble's Law
      - another empirical formula
      - $Z = H \cdot d / c$  ( $Z = (l - l_0) / l_0$ ,  $H = 74.3 \pm 2.1 \text{ (km/s)/Mpc}$ )

# Collection of datas

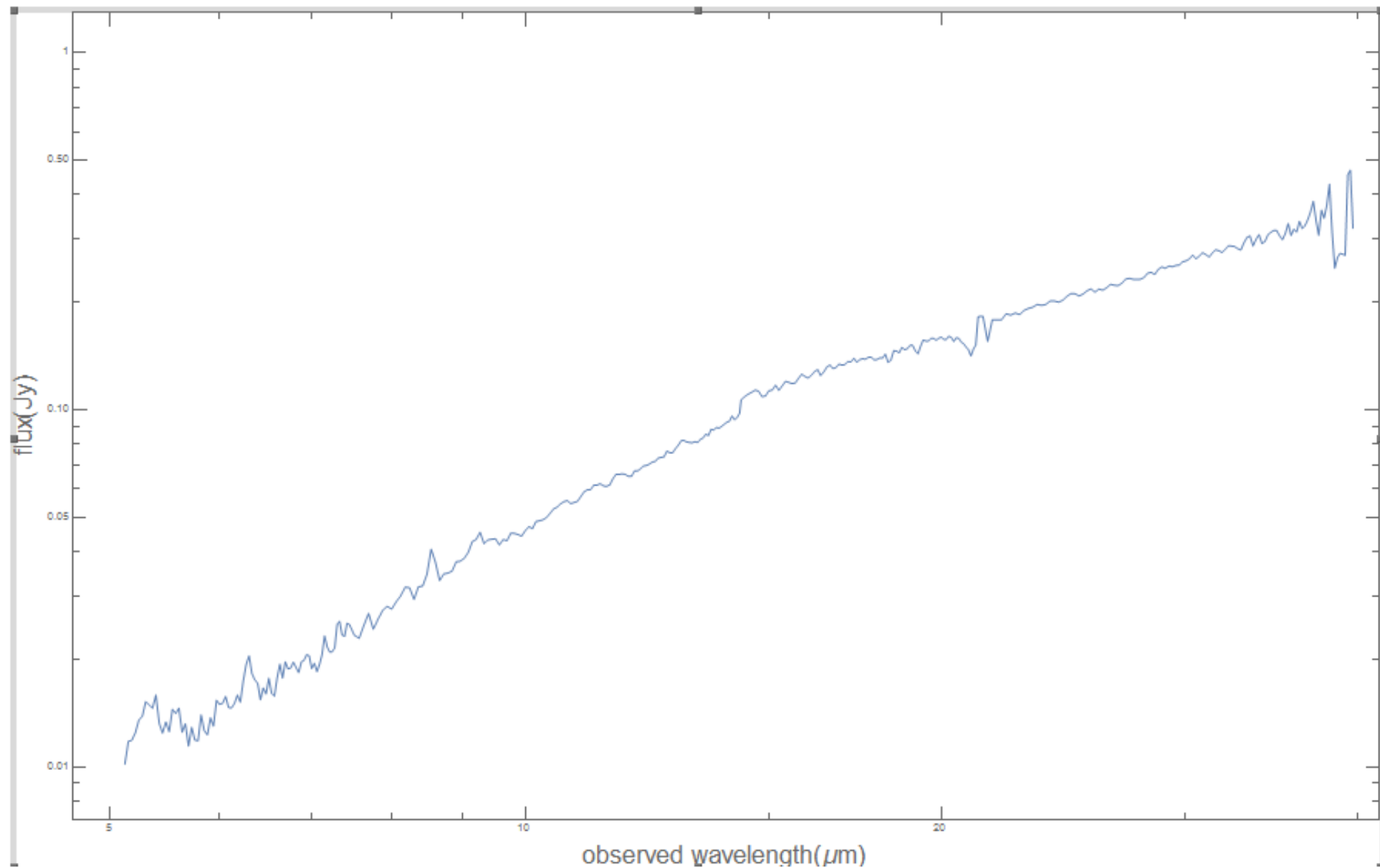
- spitzer space telescope
  - an infrared space observatory
  - NASA

# Download and Extract data (Spice)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	wave length( $\mu\text{m}$ )	flux (Jy)														
2	5.12652	-0.000175														
3	5.15676	-0.000536														
4	5.187	0.007221														
5	5.21725	0.013506														
6	5.24749	0.014174														
7	5.27773	0.014151														
8	5.30797	0.016014														
9	5.33821	0.013205														
10	5.36846	0.014696														
11	5.3987	0.014957														
12	5.42894	0.01487														
13	5.45918	0.01448														
14	5.48942	0.012874														
15	5.51967	0.011917														
16	5.54991	0.013127														
17	5.58015	0.014559														
18	5.61039	0.012808														
19	5.64063	0.012325														
20	5.67088	0.011419														
21	5.70112	0.010438														
22	5.73136	0.011612														
23	5.7616	0.011856														
24	5.79184	0.012240														

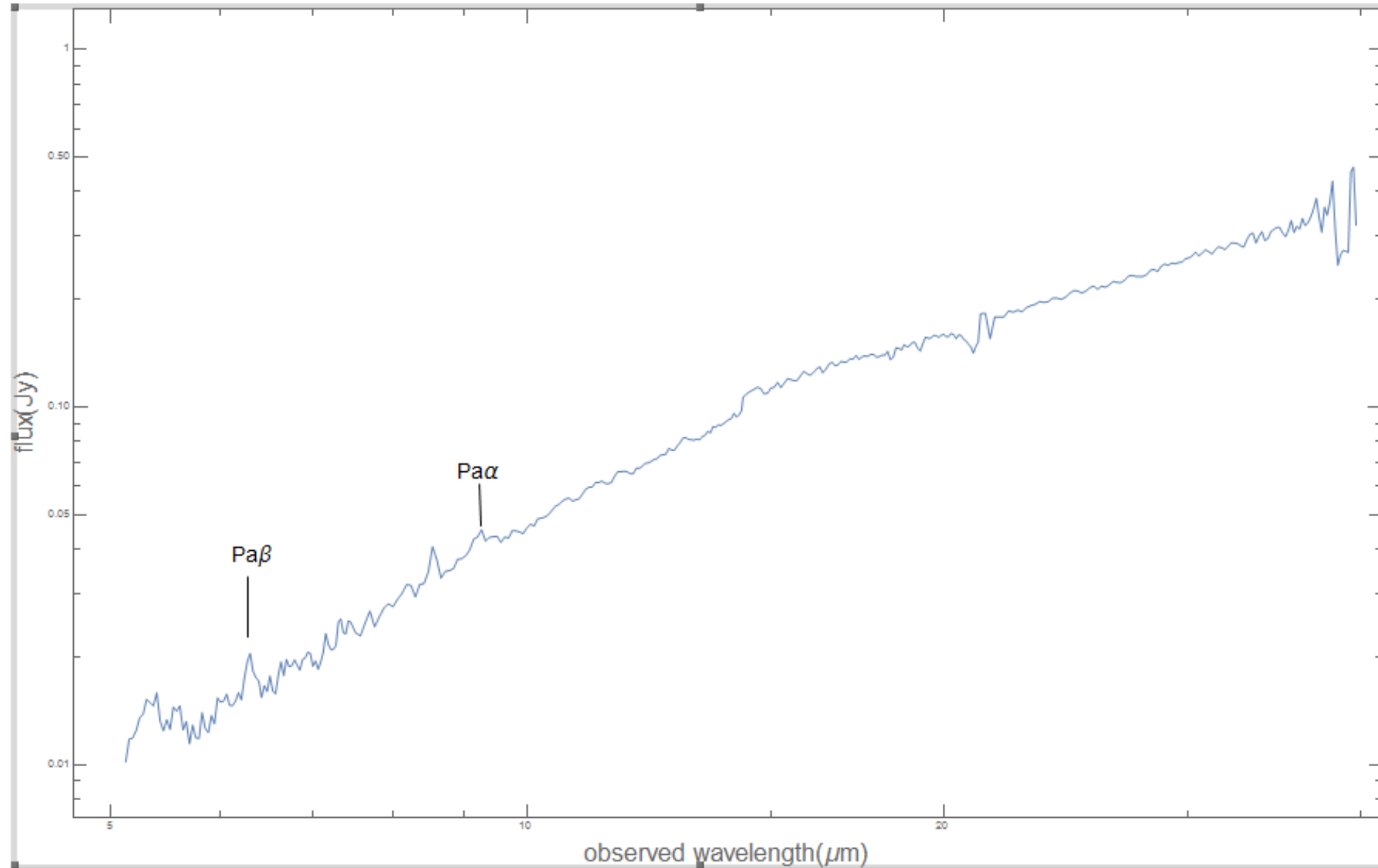
Navigation: 5-9 (1) | 5-9 (2) | 7-15 (1) | 7-15 (2) | 13-21 (1) | 13-21 (2) | 19-40 (1) | 19-40 (2) | + | : | < |

# Plot (mathematica)





# Plot (mathematica)



# Observed wavelength

- Observed wavelength of Pa $\alpha$ :9.26  $\mu\text{m}$
- Observed wavelength of Pa $\beta$ :6.30  $\mu\text{m}$

# Rest wavelength

- Rest wavelength of Pa $\alpha$ :1.85  $\mu\text{m}$

Pa I	1 847.861		3000						u2
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- Rest wavelength of Pa $\beta$ :1.18 $\mu\text{m}$

Pa I	1 179.173		10000						u2
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- $Z=4.01$ ( $\text{pa}\alpha$ )
- $Z=4.34$  ( $\text{pa}\beta$ )
- Average and Bringing it into the Hubble's law
  - Average of  $Z=4.18$
  - $D=16.88\text{gpc}$

# Error analysis

- *Hubble constant*
- Interference of other space object
- Limits of spitzer

# Reference documentation

- [1] B. T. Soifer, V. Charmandari. SPITZER INFRARED SPECTROGRAPH (IRS) OBSERVATIONS OF THE REDSHIFT 3.91 QUASAR APM 08279+5255[J]. The Astrophysical Journal Supplement Series, 2004 September: 151–154
- [2] Dondervogel 2. Stellar parallax[G]. [https://en.wikipedia.org/wiki/Stellar\\_parallax,2015/,6.15](https://en.wikipedia.org/wiki/Stellar_parallax,2015/,6.15)
- [3] Drbogdan. Redshift[G]. <https://en.wikipedia.org/wiki/Redshift,2015/,6.15>
- [4] KasparBot. Cepheid variable[G]. [https://en.wikipedia.org/wiki/Cepheid\\_variable,2015/,6.15](https://en.wikipedia.org/wiki/Cepheid_variable,2015/,6.15)