Kishlay Singh

classmate

Date
Page

8/03/21

Kishlay Singh
2003121005

Undertaking →

I, Kishlay Singh (2003121005), herby declare that during the course of this exam, have NOT USED any means of communication through phone, chat or any messaging, VOIP or social media app to discuss regarding this exam with any human or any bot.

Kishlay Singh
08/03/21

Que 1 →

(a) Brightness of a star in a particular band λ is expressed by:-

$$m_\lambda = M_\lambda + 5\log_{10} d - 5 + A_\lambda \quad -(1)$$

where

m_λ → apparant magnitude of star
M_λ → absolute magnitude of star
d → distance to the star in parsec
A_λ → number of magnitudes by which the star is extincted.

Intensity of light from a source depends upon the optical ~~length~~ depth to the source

$$\cancel{I_\lambda} = I_{\lambda 0} e$$

$$I_\lambda = I_{\lambda 0} e^{\tau_\lambda} = d \quad -(2)$$

Kirtley Sng

2003121005

with an optical depth τ_λ of zero, the intensity of light is not diminished. The difference in magnitude between two sources can be expressed as:-

$$m_1 - m_2 = -2.5 \log_{10}\left(\frac{F_1}{F_2}\right) \quad -(3)$$

Combining (2) and (3), we get

$$m_\lambda - m_{\lambda 0} = -2.5 \log_{10} e^{-\tau_\lambda} = 2.5\,\tau_\lambda \log_{10} e$$

$$= 1.086\,\tau_\lambda = A_\lambda$$

(b) $M_H \approx -9.5(\log_{10} W - 2.5) - 21.67$

$$M_H = -9.5(\log_{10} 70 - 2.5) - 21.67 = -15.44$$

$$D_{pc} = 10^{(M_H - m_H - 5)/5}$$

$$D_{pc} = 10^{(-15.44 - 15.1 - 5)/5} = 12.82\,Mpc$$

~~In the plot of fundamental plane, open air~~

(C). The Fundamental plane is a set of bivariate correlations ~~connect~~ connecting some of the properties of normal elliptical galaxies.

We know that in the Coma Cluster, all of the elliptical galaxies lie close to a plane in the 3-Dimensional 'space' of central velocity dispersion σ, effective radius R_e, Kishaly...

2003121005

and surface brightness $I_c = I(R_c)$. Approximately we have

$$R_c \propto \sigma^{1.2} I_c^{-0.8}$$

The fundamental plane relation reflects some basic processes, still to be understood, by which elliptical galaxies form. We see the galaxies at $z \sim 1$ as they were when the cosmos was half its present age. They are brighter than those nearby, and do not follow the same fundamental plane; their mass to light ratios are roughly 5 ~~times~~ times.

The tully-Fisher and Faber-Jackson relations specify a connection between luminosity and kinematic property of galaxies. Such a relation was indeed found and is known as fundamental plane.

~~Ques 4.~~

Ques 5 →

~~(a). FR-II Galaxies:-~~

~~This class comprises of luminous radio sources with hot spots in their lobes at distances from the centre which are such that $R_{FR} > 0.8$. These sources are called edge darkened which was particularly apt terminology~~

Kishly Sh
2003121005.

Que 5 →

(a). ~~FR II~~ FR II Galaxies:-

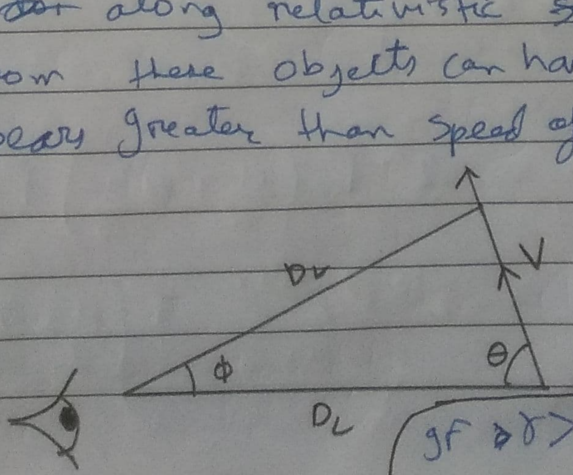
Radio emmissions are in high luminosity in FRII in the radio lobes with prominent hotspots and brighter outer edges. Jets are more collimated in FRIIs

FRIIs have optical emission lines about an order of magnitude stronger than FRI. FRII morphologies are well defined by their clear outer hotspots and/or bright edges.

Radio loud ~~glax~~ galaxies:-

Radio loud quasars ~~bars~~ behave exactly like radio-quiet quazars with the addition of ~~jets~~ emission from the jets. Thus showing strong optical continuum emission, broad and narrow emission lines and strong X-ray emission, together with nuclear and often radio emission.

(b). Superluminal motion: is apparently faster-than-light motion seen in radio galaxies, BL Lac objects, quazars, blazars and ~~a~~ recently also in some galactic sources called micro quazars. Burst of energy moving out ~~for~~ along relativistic ~~speeds~~ jets emmited from these objects can have a proper motion that appears greater than speed of light.



$$\beta_T^{max} = \frac{\beta \sin\theta}{1-\beta\cos\theta} = \frac{\beta/\gamma}{1-\beta^2}$$

$\text{if } \gamma >> 1,\ \beta_T^{max} > 1$

Kishlay Singh

2003121005

Ans 5

(c) → Flat Spectrum Radio Quasars - AKA FRSQs.

They are more distant than BL ~~a~~ Lac objects or blazars. They are also more luminous than blazars and have luminosities in the order of 10^{47} erg/s. They show strong emission lines and have higher lorentz factor. The equivalent width (EW) of them fixed spherical emission lines $> 5A°$. ~~These~~ Their spectrum follows a ~~pord~~ power law given as $S_V \propto V^{-\alpha}$, where $\alpha < 0.5$.

Narrow line Seyfert 1 - Seyfert galaxies are radio ~~are~~ quiet AGNs, i.e. they do not have any radio emission, Type 1 Seyferts are divided into two class called ~~the~~ Narrow line seyefert 1 and broad line seyfert 1. ~~&~~ Narrow line Seyfert 1 ~~&~~ NLS1 are those objects whose emission spectrum shows ~~ma~~ ~~the~~ narrow line features, i.e. redshift in smaller. They are intriaxially spiral galaxies with ~~width~~ high surface brightness cores.

Kshitij Garg
200121005.

(d). ~~Ring~~ Ring like structure of M87 blackhole.

The Centre of the ringlike structure is called the shadow of the blackhole. The ring is basically made up of hot gas, plasma and dust moving at relativistic speeds at a very high temperature.

The ring is brighter at one side because the blackhole is rotating, and thus material on the side of the blackhole turning toward Earth has its emission boosted by Doppler effect.

Also the back side of the black hole is also visible due to strong gravitational lensing.

The ring like structure is basically the matter in the accretion disk moving inside the blackhole.

Kishley Singh
2003121005.

classmate
Date
Page

Ans 4 →

(a).

$\gamma = 10^6$

energy of photon = 7 kev

energy = $h\nu$

frequency = $\nu = \frac{7 \times 10^3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$

$\nu = 1.69 \times 10^{18}$ Hz

$\nu = \frac{1}{2\pi} \times \gamma^2 \times \frac{eB}{m_e c}$

$B = \frac{2\pi m_e \nu c}{\gamma^2 e}$

$= \frac{2 \times 3.14 \times 9.1 \times 10^{-31} \times 1.69 \times 10^{18} \times 3 \times 10^8}{10^{12} \times 1.6 \times 10^{-19}}$

$B = 1.81 \times 10^4$ Tesla

Energy of photon in Inverse - Compton Scattering

$E = \frac{4}{3} \gamma^2 (h\nu) = \frac{4}{3} \times (10^6)^2 \times 7 \times 10^3$ eV

$= 9.33 \times 10^{12}$ KeV

$E = 9.33 \times 10^6$ GeV

Kshitij Sr
2003121005

(b) $\gamma = 10^6$, $B = 5G$

~~Booo~~

Calling time =>

$$t = 7.8 \times 10^8 \times \frac{1}{B^2 \gamma} = \frac{7.8 \times 10^8}{25 \times 10^6}$$

$$t = 31.2 \text{ sec}$$

Synchrotron cooling time scale = 31.2 seconds

(d). ~~P(E) =~~ Energy spectrum of electron

$$N(E) = KE^{-p}\, dE$$

We have to integrate for all frequencies.

Fractional polarization :-

$$\Pi = \frac{\int_0^\infty G(x)\, x^{(p-3)/2}\, dx}{\int_0^\infty F(x)\, x^{(p-3)/2}\, dx}$$

~~$\int_0^\infty x^\mu G(x)\, dx = 2^\mu \Gamma$~~

$$\int_0^\infty x^\mu G(x)\, dx = 2^\mu \Gamma\left(\frac{\mu}{2} + \frac{4}{3}\right) \Gamma\left(\frac{\mu}{2} + \frac{2}{3}\right)$$

$$\int_0^\infty x^\mu F(x)\, dx = \frac{2^{\mu+1}}{\mu+2} \Gamma\left(\frac{\mu}{2} + \frac{7}{3}\right) \Gamma\left(\frac{\mu}{2} + \frac{2}{3}\right)$$

Keshav Sharma
2003121005

Using this we get

$$\Pi = \frac{2^{(p-3)/2}\,\Gamma\left(\frac{p-3}{4}+\frac{4}{3}\right)\Gamma\left(\frac{p-3}{4}+\frac{2}{3}\right)\left(\frac{p-3}{2}+2\right)}{2^{(p-3)/2+1}\,\Gamma\left(\frac{p-3}{4}+\frac{7}{3}\right)\Gamma\left(\frac{p-3}{4}+\frac{2}{3}\right)}$$

$$=\left(\frac{p+1}{4}\right)\times\left(\frac{\Gamma\left(\frac{p}{4}+\frac{7}{12}\right)}{\Gamma\left(\frac{p}{4}+\frac{19}{12}\right)}\right)$$

$$\Pi = \frac{p+1}{4}\times\frac{1}{\left(\frac{p}{4}+\frac{7}{12}\right)} \qquad \left[\Gamma(n+1) = n\Gamma n\right]$$

$$\Pi = \frac{3(p+1)}{3p+7}$$

For energy spectrum of e^- $\quad p \simeq 2$

$$\Pi = \frac{3\times3}{13} = 0.6923$$

$\Pi = 0.6923$ or 69.23%.

Hence the maximum value of linear polarization for a power law distribution of electrons emitting Synchrotron radiation is:- $69.23\% \approx \underline{70\%}$.

Kuś Sh
2003121005.

~~Que 2~~ →
~~(a).~~

Que 3 → Upto a red Shift of z=3, colour bimodality
(a) can be observed in galaxies. This means that at a young age of cosmic epochs, galaxies with an old stellar population consisted with those actively forming stars. This ~~stars~~ shows that even at large redShifts, many galaxies exist with a passively ending stellar population.

Galaxies ~~k~~ Shows a bimodal distribution in the green - red colour space with two peaks, one corresponding to luminous red galaxies called red Sequence ~~st~~ and the other correspondig to the less luminous blue ~~gal~~ galaxies called blue cloud galaxy. The spread of red galaxies is less than that of blue galaxy, implying that their colour is very well defined. ~~The~~ The red galaxy have an old stellar population with essentially no star formation activity. The spread in colour of blue cloud galaxy presumably reflects the variation in rate of star formation in blue galaxies..

Kaly S

2003121005

classmate

Date

Page

(b) ~~At time~~

Assumptions made:-

→ At time $t=0$ of formation, no metals are present in the ~~glat~~ galaxy ($z=0$ at $t=0$)

→ No Star at time of birth

→ Galaxy is a closed system, no feedback.

→ Time scales of Stellar evolution are smaller compared to time scales of galactic evolution.

$$M_g(t) + M_s(t) = M_{Tot}^{bar} = \text{Constant}$$

M_H = mass of heavy element ($A>2$).

$$Z = \frac{M_H}{M_g}$$

and let yield be p.

Let δM_s ⇒ Mass in stars + SN remanant after time t.

→ $p\,\delta M_s$ ⇒ amount of metals injected into surroundings

→ $Z\,\delta M_s$ ⇒ amount of metals locked in Stars and remants

$$\delta M_h = p\,\delta M_s - Z\,\delta M_s = (p-z)\,\delta M_s$$

(metals available in gas)

$$Z = \frac{M_h}{M_g} \;;\; \delta Z = \frac{\delta M_h}{M_g} - \frac{1}{M_g^2} M_h\, \delta M_g$$

[illegible]

2003121005

$$= \frac{\delta M_h}{M_g} - z\frac{\delta M_g}{M_g}$$

$$\cancel{\frac{\delta M_h}{M_g} - \frac{z}{M_g}}$$

$$\delta M_h = (p - z)\,\delta M_s \; ; \qquad \delta M_s = -\delta M_g$$

$$\delta z = -p\,\frac{\delta M_g}{M_g}$$

Assuming p is constant, we have.

$$z(t) - z(0) = -p \ln\left(\frac{M_g(t)}{M_g(0)}\right)$$

$$z_t = = p \ln\left(\frac{M_g(t) + M_s(t)}{M_g(t)}\right)$$

$\therefore \; z(t) = p - \ln u \qquad$ where $u = \dfrac{M_g(t)}{M_g(t) + M_s(t)}$

This particular model vastly over predicts the number of G-dwarf (metal-poor stars) in a galaxy. This is ~~called~~ called the G-dwarf problem. It essentially predicts that about half of the F and G main sequence stars should have $z < 0.25 < z_0$. These are many of the stars observed today. But we find that low metallicity is actually quite rare in these types of stars. The discrepancy is far too large to be explained by selection basis. Hence we conclude that the model is over simplified.

Kashav Sg

2003121005

(c). $z(t) = z(t=0) + p \ln \left(\frac{Mg(t=0)}{Mg(t)} \right)$ — ①

$z(t=0) = 0.15\, z_0$

$z(\text{now}) \approx z_0$

$\frac{Mg(t=0)}{Mg(t)} = \frac{50}{13}$

Putting in the eq ①, we get

$z_0 = 0.15\, z_0 + p \ln(50/13)$

$p = \frac{z_0(1-0.15)}{\ln(50/13)} = 0.63 z_0$

~~p = 0.63 z0~~ $\underline{p = 0.63\, z_0}$

Que 2 (a) ⟶ $v = H_0 d$

$d = \frac{v}{H_0} = \frac{6750}{70} = 96.4\, Mpc$

Effective radius = $96.4 \times 10^6 \times 50 \times 60$ AU

$= 289200 \times 10^6$ AU

Using Virial theorem.

$2E_{kin} + E_{pot} = 0$

$E_{kin} = \frac{M}{2} \langle v^2 \rangle$, $E_{pot} = -\frac{GM^2}{r_G}$

where r_G is gravitational radius

Kaby Sen

2003121005

Using the ~~Abom~~ above relation, ~~vogl~~ we get

$$M = \frac{R_G \langle v^2 \rangle}{G} = \left(\frac{2.5 \times 4.3 \times 10^{24} \times (900 \times 10^5)^2}{6.7 \times 10^{-8}}\right)$$

$$= 1.3 \times 10^{48} \text{ gm} = 1.3 \times 10^{45} \text{ Kg}$$