Radio Astronomy

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Example Questions

Hello, welcome to this third lecture of week 7. We will continue our discussion with some more examples about the problems which we have dealt in this particular week and some associated problems also. So the first example we are looking into is from the positional astronomy. We have a source which is R8 is 12 hour 30 minutes and declination is 0. So alpha is 12 hour 30 minutes and delta is 0. So astronomers decided to check it out and set out to observe it with their own telescope which is located at 78 degree west longitude and 35 degree north.

So the lat is 35 degree north and the longitude is 75 degree west. First they first check their computers and see that the current LST at the telescope is 3 hours of LST. So LST is also given is equal to 3 hours. Okay so what are the RA and the dec of the astronomers zenith.

So the RA of the zenith is given by the LST because we have known that at the zenith our angle equal to 0 so RA is equal to LST. So then LST is 3 hours so RA becomes 3 hours and declination is the local latitude which is 35 degree north right yeah so declination is also 35 degree plus 35 degree. The next question is what is the current hour angle of the radio source that's interesting point the current hour angle how can it be figured out the hour angle is equal to LST minus the RA. Okay now did we get anything about the RA the RA of the surface is 12 30 minutes and the LST is 3 hours. So the hour angle is then 3 hours which is the LST minus the RA.

This is given by this but note that this is minus 9 hours so that means the source is still 9 hours or so away from the transit so this so far away from next transit. Okay what is the third question the third question is is the radio source above or below the horizon at this time. So we determine the altitude we calculate the altitude of the source so this means some mismatch so altitude is calculated as because 35 degrees is zenith the altitude of the source is 55 degree that's the altitude of the particular source. Okay so it's when it at the transit we can say that the transit the source is definitely can be will be above the horizon. Example number two we calculate the radio telescope has a collecting area of 1.

2 meter squared to observe a radio source at a frequency of 1420.4 megahertz with a bandwidth of 2 megahertz you measure a detected power of 1.2 times 10 to the power minus 22 what is the flux density of the source observed. It's kind of a bit of a going backward and try to again explain if you have any further problem. So this links the source flux density with the power the effective

area and the bandwidth so they are linked in this manner.

 Okay and so if you put simply put substitute all the values you will get the final answer. So we decided we'll go back a little bit and again go forward and so every week from now we will go back to some old concepts as well. Example three the data from our radio telescope that can detect both left circular and right circular polarization this is typo for left and right circular polarizations at the same time are processed through a program that calculates stokes parameter. The results indicate that I the stokes I parameter is given by 0.5 chance keeper beam and Q is 3 milli jansky per beam U is 4 milli jansky per beam and V is 0.

 Does this radiation have a non-zero polarization if so what kind of polarization does it have characterize the polarization. The radiation is unpolarized only if Q U and V are equal to 0. Since Q and U are non-zero the radiation is polarized Q and U are measures of the linear polarization while V is a measure of circular polarization. Since V is equal to 0 and Q and U are not 0 the radiation is linearly polarized. The percent polarization of linear polarization is given by L over I where L is the quadrature addition of Q square plus U square and square root of that so if you do that you figure out that the percentage linear polarization is given by 1%.

  The position angle can be given by theta is equal to half tan inverse of this value so Q over U so U over Q and it is given by 63.4 degree. Okay so that's it. Next example a pair of antennas are aligned in the east-west direction to be used as an interferometer with a fixed baseline B. Antennas are pointing at a particular source doesn't matter the alpha is given the array is given by this 8 hours 54 minutes and 40.

86 seconds and delta is given by plus 20 degrees 6 minute and 30 second 30.6 seconds according to the J2000 epoch. At the time of observation OJ287 is an hour-an-hour angle of 2 hour plus 2 hours observing at a wavelength of 1.25 centimeters we obtain a cross correlation and find the rate of change of phase to be equal to minus 0.432 radians per second.

 We can use this data to measure the baseline length what length to be infer. Okay so we use this standard formula of using the fringe rate and we can just substitute the values we know if we substitute the values we know what is the delta so delta we know which is equal to plus 20 this thing 0.6 30.6 so delta is 20 degree 6 30.6 so 6 minutes 30.

6 half seconds that is given we know the baseline we do not know the baseline we know the lambda lambda is given by 1.35 centimeters okay and fine since the baseline is purely this thing G equal to 0 that is okay time is 2 hours that is 7200 seconds for the declination we convert the arc seconds into fraction of a degree so we converted the entire thing into delta equal to 20.1085 degree the product of omega e times time is given is gives you 0.5256 which can be expressed as 30.1 degree okay so 0.

432 is radians per second you know how many seconds has evolved we can put that in so finally the b comes out to be the yeah so if you put all the values together you finally get the baseline length given by 15.65 meter that's how you derive the baseline length okay the next question is

after the baseline is measured we use this interferometer to observe a new source with coordinates alpha given as 13 hour 24 minutes 12.909 seconds and 8 delta s plus 48 degree 48 minutes and 11.8 seconds the measured fridge frequency is given by this so what was the hour angle which we observed this new source so yeah then you have the value a and b b and solve for t so this is the in terms of degree i have the degree also delta is converted into from degree minute and second into degree since the fridge frequency is positive the source is still approaching transit that is also known we then get the cosine t value is given over here and we can calculate the omega f from there and then the t that gives us 10 300 seconds so since it is approaching the transit so it is still 2.87 hours before the transit so because it will happen 2.

87 hours after now okay so that's what you can do so basically you simply have the fridge frequency is related with the baseline and lambda and the delta of the source so that we have to substitute it and we have got this particular problem solved the submillimeter array in Hawaii is composed of next example submillimeter array in Hawaii is composed of eight dishes of six meter diameter each while the very large array in New Mexico has 27 dishes of 25 meter diameters each which array would benefit from more from the addition of another dish so the sma has interesting problem sma has eight into seven 28 baselines with one more antenna it will have eight additional baseline so 36 it is an increase of 29 percent vla has 51 baseline if you add one more that will be increased to 78 which is 7.7 percent increase so definitely with a larger array if you just add one to the smaller array which is the sma that will benefit much more than the vla so by by by definition if you add one more dish to the x a smaller array smaller array means an array which is smaller number of antenna the percentage increase in the baseline would be much more next example if a radio interferometer facility contains 25 antennas of 40 meter dish operating at 21 centimeter wavelength with 95 percent efficiency and having minimum baseline of 500 meters and maximum baseline of 35 kilometers then what is the resolution of the facility in arc seconds what is the field of view in degrees and total collecting area of the interferometer in square meter so resolution is lambda by the maximum baseline this b is nothing but the maximum baseline in an interferometer so if you convert them you get 1.24 arc seconds field of view is still remains close to the individual antenna so it links with the d which is the diameter of the so it links with the d which is the diameter of the antenna of each antenna so it remains 18.05 arc minute is at a frequency at a 40 meter dishes 21 centimeter yeah this is what it is total cutting area is given by area a total of 25 antenna this is the efficiency pi this e by 2 whole square so if you put all the values you simply get to this calculation pretty simple by now we have done more examples on this kind of things example number seven consider you are located at a latitude of 22 degree 7196 degree north and longitude 75.8577 degree east if you are trying to observe a source with r a of 12 hour 10 minute 15.

3 seconds and detonation of 22 degree 43 minute 10.56 seconds then what is the correct rise and set time of the source in lst so the lst is um so six hour is the so essentially the detonation is almost equal to the latitude of the observer more or less so you have a detonation equal to the latitude so detonation of the source is around 22 degree 43 minutes and which is very close to this 22.7 196 degree north okay so the source will pass through the zenith that means the source is equally up and equally down so in an in a day you have 24 hours if it is equally up meaning the uptime is about 12 hours and downtime is also 12 hours that means it is not visible for 12

hours and is visible for 12 hours so the r a minus six hours is so we want to know is the rise and set time in lst now remember when it transits when there is crossing the zenith the hour angle is equal to zero at the transit so at the transit the r r a is equal to the lst so the lst of the rise is six hours before and lst of the set is six hours after the ra so you simply just subtract six hours to calculate the ra in lst that is six hours 10 minutes between point three seconds and set is six hours after the ra and that is 18 hours 10 minutes and 15.3 seconds so these calculations are very very powerful if you simply remember that that diagram we did where you have an observer and you connect the north and the south pole so if you're connecting to the north and the south so you draw the and the zenith is here so you draw the imaginary great circle and this is passing through your zenith so any source which is passing through the zenith will be delta will be equal to your latitude of the place and so you can calculate the rest the meaning of this at any transit the hour angle is zero at transit so ha equal to zero and ra is equal to the lst so with that you can calculate a lot of different things let's take up another example in this same method a cosmic source is located at a latitude galactic latitude of plus eight degree 32 second uh 32 minute 48.63 seconds and galactic magnitude of minus 71 degree 12 minutes and 40.

4 seconds find the position to the equatorial coordinate system if you follow the x the coordinate transformation given in the lecture notes you just simply put the values and you will finally find that alpha and delta in epoch of 1950 is given by this so it's simply substituting the values and we haven't derived it it's a bit cumbersome and we will stay away from it because it's just a factory course in the astronaut thanks what is the far field distance of the green bank telescope and green bank telescope is for diameter of 100 meters and if you're observing at 21 centimeter lambda then we know that there was this few things right there was when you have a radiating dipole we have we have three different zones we have first zone which is the near reactive one we have the second zone intermediate zone which is the phenyl zone and we have the third zone which is the far field or we also call it fernhoffer zone this boundary between the near fennel zone and the homo zone is marked as 2d squared over lambda so the d is a dimension so that the 100 meter is the d so d equal to 100 meter and lambda is also equal to 81 centimeters so if you put that you find out this boundary is 95.24 so any r which is greater than 95.24 defines the far field kilometers of course yeah thank you i i hope that you you got benefited from this discussion of this additional examples we particularly trying to incorporate more and more additional examples and going through them tenuously just to help you understand different concepts we are not only restricting this to the existing weeks lectures but also we are extending them to the previous weeks lectures as well for your help we are also going to start this week this week our next two lectures will be on introduction to python we plan to introduce python and show you some examples on how python can be used for demonstrating Fourier transforms for example for some radiation patterns for example and it's anyway it's a very big good tool and you need to have expertise with you whether you're from science and engineering so it's at a different outset having a python expertise is always useful but for the context of this particular course we will introduce python this week and we will utilize the python's different routines to show you the demonstration of Fourier transform convolution and also a little bit of radiation patterns of very simple radiating bodies hope you've liked our lectures so stay tuned for the next lecture thanks for joining me today thank you