Astronomical Refraction above Kufa Astronomical observatory

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Abstract :

Astronomical refraction addresses ray-bending effects for objects outside the earth's atmosphere in relation to an observer within the atmosphere. In this paper is a study of the Atmospheric refraction and its effect on the light coming from celestial body by using Astronomic Refraction model above Kufa Astronomical Observatory at different zenith angles and different weather conditions. These weather parameters were collected from the weather link station of the observatory.

The results are perfect agreement with other models

Keywords: Atmospheric refraction, altitude angle, Kufa Astronomical Observatory.

الانكسار الفلكي فوق مرصد الكوفة الفلكي

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الخلاصة:

الانكسار الفلكي يمثل انحناء الضوء الصادر من جسم خارج جو الارض عند مروره خلال طبقات الجو نسبةً الى الراصد على سطح الارض. في هذا البحث تمت دراسة الانكسار الفلكي وتأثيره على الضوء القادم من الجسم السماوي باستخدام موديل الانكسار الفلكي فوق مرصد الكوفة الفلكي لزوايا سمتيه مختلفة وظروف جوية مختلفة ،حيث جمعت البيانات من محطة الارصاد الجوية التابعة للمرصد الفلكي.

وجد ان النتائج متوافقة الى حد كبير مع موديلات اخرى .

كلمات مفتاحية: مرصد الكوفة الفلكي ، الانكسار الفلكي ، زاوية السمت الفلكية

1.1: Introduction

In Astronomy and geodesy we are use measurements of electromagnetic signals which propagate through the Earth's envelope. Atmospheric refraction is the difference between the direction before the light of a celestial body enters through the atmosphere and the direction when it reaches the observer. At an ideal case, atmospheric refraction does not affect the azimuth of a celestial body but effect only the zenith distance. By comparison with the other factors which affect the direction of the objects[1,2].

The real part of the atmospheric index of refraction is a function of pressure, temperature and frequency. Many interesting low-altitude refractive effects exist because of tropospheric variations in density and water vapor partial pressure as a function of position so the effect of refraction in the atmosphere shifts the observed position of a star towards the observer's zenith, So it is an effect specific to given location [3]. It is well known that refraction by the earth's atmosphere may be important for photochemical calculations near the terminator. For example, Anderson and Lloyd (1990) and DeMajistre et al. (1995) presents detailed calculations for the effect of refraction on the optical path. Besides the lengthening of the sunlit day, (at large solar zenith angles (≥90))with the inclusion of refraction reduces the optical depth of the direct beam in most cases, when the radiation is enhanced [3,4] .

S. Cavazzani, S. Ortolani and C.Barbieri.(2011), are calculated the delay of the arrival times of visible photons on the focal plane of a telescope and its fluctuations as a function of local atmospheric conditions :temperature, pressure , chemical composition and telescope diameter, So they described a theoretical mathematical model for calculating the radius through the study of delay time fluctuations[5].

1.2:Astronomic Refraction model:

When light refracted by atmosphere, The direction of an object differs from the true direction by amount depending on the atmospheric conditions along the line of sight. This refraction varies with atmosphere density, pressure and temperature[5,6].

If the object is not too far from the zenith ,the atmosphere between the object and the observer can be approximated by a stack of parallel planar layers fig(1). Each of it has a certain index of refraction(μ_i) at outside the atmosphere,

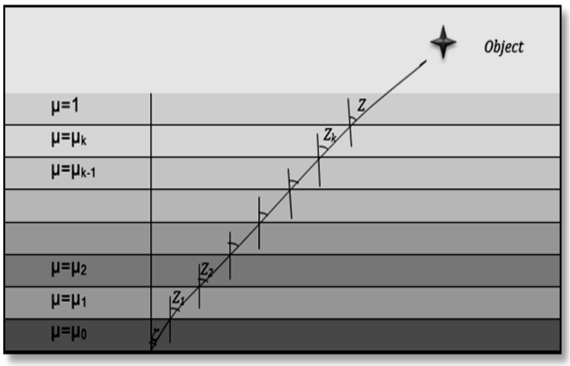

Fig.(1)Refraction of light ray traveling through the atmosphere layers.

From fig (1) get the following equations for the boundaries of the successive layers : Let the zenith distance was (Z) and the apparent one (ζ) from fig (1) get the following equations for the boundaries of the successive layers :

$\mu \sin z=\mu_k \sin z_K$ (Snell's Law)………(1.1)

$\mu_2 \sin z_2=\mu_1 \sin z_2$……………………...(1.2)

$\mu_1 \sin z_1=\mu_O \sin\zeta$ ……………………..(1.3)

if the refraction angle $R=z-\zeta$ is small and is expressed in radians then:

$\mu_O \sin\zeta = \sin z=\sin (R+\zeta)=$

$\sin R \cos \zeta +\cos R \sin \zeta$

$\approx R \cos \zeta+\sin\zeta$ ………………………..(1.4)

thus we get:

$R=(\mu_O-1)\tan\zeta$ ………………………. (1.5)

The index of refraction depends on the density of the air ,which further depends on the pressure and temperature .when the altitude is over 15^0 ,we can use an approximate formula[3,7]:

$$R = \frac{P}{T+273}\ 0.00452^0 \tan(90 - a) \qquad \text{........(1.6)}$$

Where: (a) is altitude (in degrees), (T) is Temperature (in Celsius) ,(P) pressure (in millibars)and (R) is Astronomic Refraction (in arc sec). An approximate formula for the refraction at altitudes(15^0 - 30^0):

$$R = \frac{P}{T+273}\ \frac{0.1594 + 0.0196a + 0.00002a^2}{1 + 0.505a + 0.0845a^2} \qquad \text{.........(1.7)}$$

These formulas to calculate the Astronomic Refraction in terms of implemented weather parameters(PandT) and altitude angles [3,7,8].

1.3: Data and calculation

The atmospheric data was collected from the Weather link station which belong to Kufa observatory for the period (1 \ 5 \ 2011 to 30 \ 4 \ 2012) and the results were obtained as shown in table(1)(where z=90-a)**:**

Table(1)The Astronomic Refraction from date of 1 \ 5 \ 2011 to 30 \ 4 \ 2012

Date	P(hpa)	T(C^0)	R(arc sec) a=5, Z=85	R(arc sec) a=10, Z=80	R(arc sec) a=15, Z=75	R(arc sec) a=20, Z=70	R(arc sec) a=25, Z=65	R(arc sec) a=30, Z=60
15/5/2011	1007.73	25.50	599.582	297.496	195.77	144.589	115.622	96.342
15/6/2011	1006.93	30.66	588.935	292.213	192.294	142.022	113.569	94.632
15/7/2011	998.00	39.84	566.586	281.124	184.997	136.632	109.259	91.040
15/8/2011	1001.87	34.33	578.969	287.268	189.040	139.619	111.647	93.030
15/9/2011	1002.53	29.70	588.229	291.863	192.064	141.852	113.432	94.518
15/10/2011	1014.40	26.39	601.760	298.577	196.482	145.115	116.042	96.692
15/11/2011	1015.47	13.76	628.924	312.055	205.351	151.665	121.280	101.057
15/12/2011	1023.33	10.10	641.983	318.534	209.615	154.815	123.798	103.156
15/01/2012	1020.67	10.27	639.928	317.515	208.944	154.319	123.402	102.825
15/02/2012	1018.67	16.95	623.963	309.593	203.731	150.469	120.323	100.260
15/03/2012	1010.27	22.87	504.795	300.896	198.008	146.242	116.943	97.443
15/04/2012	1008.00	24.02	602.737	299.061	196.801	145.350	116.230	96.849

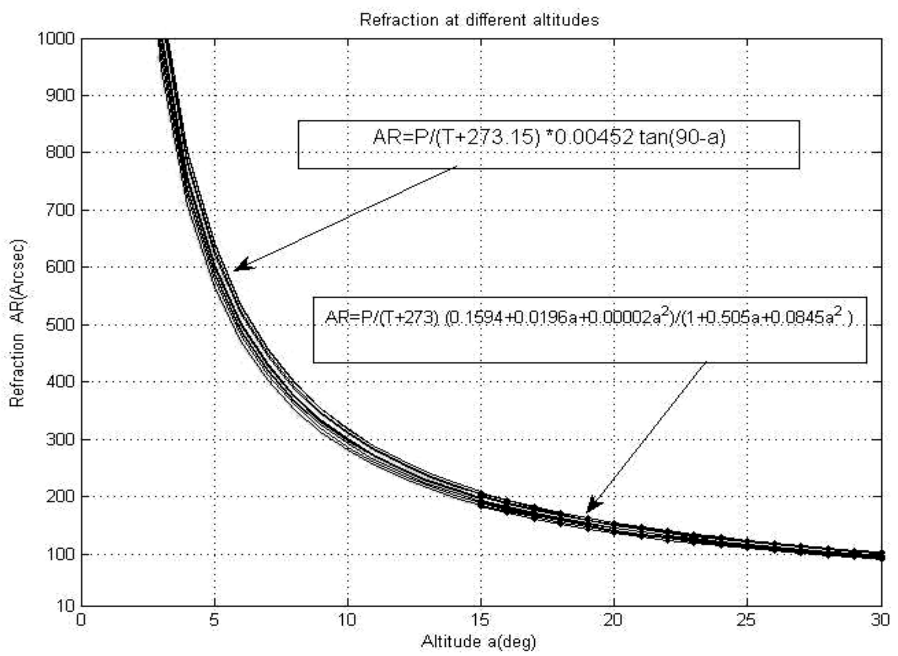

Fig.(2) Astronomic Refraction at different altitudes 1 \ 5 \ 2011 to 30 \ 4 \ 2012

1.4:Results and discussion:

Atmospheric Refraction above Kufa Astronomical observatory has been simulated . The atmospheric parameters were collected by the weather link station accompanying with the observatory type Vantage Pro2 (2009), during the interval 1/5/2011 to 30/4/2012 .The altitude of the observatory was (35 m) above mean sea level. And the geodetic coordinates (32.0 North ,44.50East).Simulation results of Atmospheric Refraction fig. (2) is decrease when altitude is increase because the weather conditions are change and the Astronomic Refraction against temperature when the temperature effect to the pressure and other condition of the weather. The results are in perfect agreement by a comparison of the results of Refraction computed by Astronomic Refraction model in table(1) and values from Saastamoinen's formula [9,10],

Saastamoinen's formula is:

$$R = 16.271'' Q\tan(Z)\left(1 + 0.0000394Q\tan^2(Z)\right) - 0.0000749'' P(\tan(z) + \tan^3(Z))$$

Where: $Q = (P - 0.156P_{W0})/T$ and (P_{W0}) is partial pressure of water vapour at observer (mb) and Z=90-a

Z(0)	Refraction(arc sec) Saastamoinen P=1005(mb),T=7C^0	Refraction(arc sec) Astronomic Refraction model P=1023.3 (mb) ,T=10.1 C^0	Refraction (arc sec) Astronomic Refraction model P=1015.47 (mb) ,T=13.76 C^0	Refraction(arc sec) Astronomic Refraction model P=998.00 (mb) ,T=39.84 C^0
60	100.53	103.156	101.057	91.040
65	124.25	123.798	121.280	109.259
70	158.66	154.815	151.665	136.632
75	208.47	209.615	205.351	184.997
80	319.18	318.534	312.055	281.124

Table (2): comparison of the values of refraction with values from Saastamoinen's formula

The bending of a light ray due to refraction in the atmosphere is be taken into account in astrometric studies when the effect of refraction at the atmosphere shifts the observed position of a star towards the observer's zenith, So it is effect specific to a given location[11,12,13].

1.5:References:

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