Refraction, gravitational lensing, negative parallaxes and dark matter

Saverio Donnini

Abstract

Here, we speculate on the causes of negative parallaxes of stars. We first summarize the concepts of refractional and gravitational lens, and we highlight the similarities between the two. We then analyze the relation between negative parallaxes and temperature of stars, and negative parallaxes and distance of stars. We observe that warmer and more distant stars show a larger number of negative parallaxes, with respect to colder and closer stars, respectively. Is refraction of light through a medium of astronomical bodies the cause of the observed stars parallaxes ? And moreover, could these astronomical bodies explain dark matter?

Refraction of a light wave and gravitational lensing

Refraction is an optical phenomenon. When a light wave passes from a medium to another one with a different refraction index, it will change its direction depending on the incident angle and the refraction indexes of the mediums. If the refraction index changes gradually, the deviation results in a curve, which will be curved in the direction of the increasing refraction index. An example of this is atmospheric refraction. The Sun light is deviated when passing through the atmosphere, due to the change in the density of air at different heights. As a result, we are able to see the Sun light already before sunrise and for a while longer after sunset. In this respect, we can think of the Earth like a refractional lens. The refractive index of a medium varies with the wavelength of light, and blue light will be deviated more than red light. That is why the sunset and sunrise are typically red. (Knight, 2017)

A gravitational lens acts similarly to a medium where the refraction index changes gradually. The light from a distant source is bended as it passes by astronomical bodies, due to the gravitational pull of these objects. In this respect, gravitational lensing and refraction are similar. They both cause deviation of light. However, it follows from Einstein's formula (Alonso & Finn, 1995), that gravitational lensing does not depend on the wavelength of light (deviation = $4GM / bc^2$).

Alonso M. & Finn E. Physics. Addison-Wesley ed., 1995, p.507.

Knight R. D. Physics for Scientists and Engineers. Pearson Education Limited, 2017.

The negative parallaxes

The parallax is the apparent change of an object's position with respect to its background as the observer changes its line of sight. If the observer moves to the right, the object position will appear shifted to the left. The angle between the two lines of sight can be used to determine the object's distance. This angle is positive in the direction of the object's displacement (Alonso & Finn, 1995). For a negative parallax, the observer moves to the right, and the object position will appear shifted in the same direction, also to the right. Different reasons are speculated for this to happen (Lee, 1943, Sazhin *et al.*, 2001, Smith *et al.*, 2003).

Distance dependence of the observed number of negative parallaxes

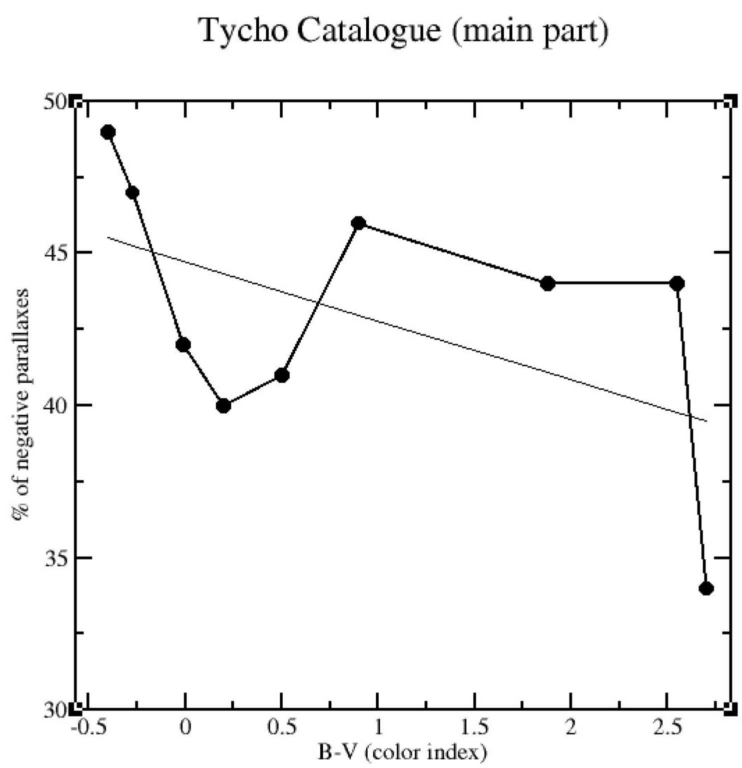
Until 1990, some hundreds of astronomical parallaxes were known, with the exception of 2 or 3, all positive. After that, thanks to the Hubble Space Telescope, a million of stellar parallaxes were measured, of which 43% are negative (data from the VizieR Catalog of the CDS Strasbourg I/239/tyc_main). The same percentage of negative parallaxes was recorded also later in 2008 by the mission GAIA, where a milliard of parallaxes was measured (data from the VizieR Catalog of the CDS Strasbourg I/345/gaia2). In general, the number of negative parallaxes increases when considering stars with distances of more than 500-1000 light-years. Interestingly, dwarf stars, which are very warm stars, show some negative parallaxes already at distances within 50 light-years (3 over a total of 820 (data from the VizieR Catalog of the CDS Strasbourg III/235B)).

Temperature dependence of the observed number of negative parallaxes

There appears to be a temperature dependence in the observed number of negative parallaxes. The Table below shows the percentage of negative parallaxes of nine groups of 200-2000 stars each. The parallaxes are read from the Tycho Catalog at CDS Strasbourg (VizieR Catalog I/239/tyc_main). The stars are grouped based on their temperature, which is estimated using the B-V color index. The lower the B-V value, the higher the temperature, and therefore, the frequency of the emitted light of the stars. For each group of stars, the number of stars with a negative parallax was counted, and the percentage over the total number of stars in the group was calculated and listed in Table. The Figure shows the percentage of negative parallaxes as a function of the B-V color index of the group. Each group's B-V is drawn in the Figure below at the center of the corresponding B-V interval considered in the Table. The Figure also shows the linear regression line through the nine points. The correlation coefficient is -0.5, suggesting a correlation between the number of negative parallaxes and the temperatures of the stars. The coldest the star, the smaller the number of negative parallaxes.

It can be noted from the Table and the Figure that group 6 has a rather high percentage of negative parallaxes, closer to the hottest stars in group 2. Group 6 includes the red giants, which are distant stars. This suggests that stars of approximately the same distance should be considered for a more significant analysis of the correlation between temperature and number of negative parallaxes. This data also shows that distance is an important factor in determining the number of negative parallaxes.

Groups	B-V	% of negative parallaxes
1	B-V < -0.4	49 (stars group with OBA=warm stars)
2	-0.3 < B-V < -0.25	47
3	-0.018 < B-V < -0.010	42
4	0.198 < B-V < 0.200	40
5	0.498 < B-V < 0.500	41
6	0.898 < B-V < 0.900	46 (cold stars KM = distant red giants)
7	1.85 < B-V < 1.90	44
8	2.2 < B-V < 2.7	44
9	B-V > 2.7	34



Alonso M. & Finn E. Physics. Addison-Wesley ed., 1995, p.28.

Lee O. J. On a reason for the appearance of negative parallaxes in the determination of the distances of stars. Annals of the Dearborn Observatory, 1943, vol. 4, pp.1-4. http://adsabs.harvard.edu/full/1943AnDea...4....1L

Sazhin, M. V., Zharov, V. E., & Kalinina, T. A. Parallax distortion by the weak microlensing effect**.** Monthly Notices of the Royal Astronomical Society, 2001, vol. 323, pp. 952-964. http://articles.adsabs.harvard.edu//full/2001MNRAS.323..952S/0000954.000.html

Smith, M. C., Mao, S., & Paczyński, B. Acceleration and parallax effects in gravitational microlensing**.** Monthly Notice of the Royal Astronomical Society, 2003, vol. 339, pp. 925-936. http://adsabs.harvard.edu/full/2003MNRAS.339..925S

VizieR Catalog I/239/tyc_main. CDS Strasbourg. https://vizier.u-strasbg.fr/viz-bin/VizieR-3?-source=I/239/tyc_main

VizieR Catalog I/345/gaia2. CDS Strasbourg. https://vizier.u-strasbg.fr/viz-bin/VizieR?-source=I/345

VizieR Catalog III/235B. CDS Strasbourg. http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=III%2F235B

Some conclusions and considerations

In the following some conclusions and considerations are presented, which support and follow from the possibility that deviation of stars' parallaxes is the result of gravitational lensing (or microlensing) or of refractive lenses.

1) The number of negative parallaxes increases with the distance of the stars from the observer (Earth). Negative parallaxes appear after about 100 light-years, and become more frequent after 500 light-years.
2) Negative parallaxes are due to deviation of the light by interposed bodies. This deviation affects parallaxes in both directions (negative and positive) and the values of 'motus proper'.
3) The number of negative parallaxes increases with the temperature of the star. This suggests that the deviation of light is dependent on the frequency of the emitting body. This conclusion would exclude gravitational lensing as the cause of the deviation, as this is not a function of the frequency (at least in its Einstenian formulation).
4) More frequent recording (monthly) of the parallaxes' angles could help correcting for the deviations of stellar parallaxes.
5) The deviation of parallaxes would require a very large number of astronomical bodies which act like lenses (gravitational or refractive). These lenses could consist of astronomical bodies of typical star sizes. The high number of light deviating bodies follows from the fact that the effective distance of a deviating body must be less than a million parts of a light-year. Given that one observes few negative parallaxes for the dwarf stars at a distance of less than

50 light-years, and that the occurrence of negative parallaxes towards the center of the galaxy is about three times larger than towards the outside, one concludes that the number of deviating bodies is possibly larger than the number of visible stars. Possibly one could try to find Einstein rings due to these dead stars, just near the stars with negative parallaxes when they are in front of a distant galaxy.

6) Following from point 5), could these astronomical deviating bodies (possibly dead stars) explain the Dark Matter? And, given this large number of dead stars, should one reconsider the age of the universe to be more than the estimated (from Big Bang) 14 milliards of years?

7) Taking a step even further, could one use these deviating astronomical bodies to support an alternative theory to the Big Bang theory? If we assume a large number of astronomical bodies which act like refractive lenses, one could propose that the red shift and the cosmic radiowave background, are the consequence of the Raman effect, which is effectively produced by refractive lenses.