

Optical Phenomenon of Mirage on the Highway

Pitri Rahmadani*¹, Adinda Anugrah Putri¹, Nadila Safitri¹, Tiara Silvina Dewi¹, Said Surya Bagustika¹

¹ *Physics Education Study Program, Faculty of Teacher Training and Education, University of Riau, Indonesia*

*Corresponding author's email:

pitri.rahmadani1145@student.unri.ac.id

Submitted: 08/08/2024

Revised: 08/08/2024

Accepted: 08/08/2024

Published: 09/08/2024

Vol. 2

No. 2

© 2024 The Authors.

This open access article is distributed under a (CC-BY License)

ABSTRACT

Indonesia with its characteristics of both seasons, namely the rainy season and the dry season. During the rainy season, the highway often becomes slippery and watery due to rainwater. However, in summer we often see the same phenomenon on the highway when the hot sun hits. This phenomenon is an optical illusion that is often referred to as a mirage. Mirages are puddle-like shadows seen on highways caused by light refraction due to differences in the density of the medium of different air layers, namely a layer of hotter air with a cooler layer of air on top. In this illusory phenomenon, the refraction of light forms a refractive angle of 90° or commonly called a critical angle, so that the incoming light rays are no longer refracted but reflected perfectly.

Keywords : *Optical Phenomena, Mirages and Highways*

1 Introduction

Wherever we go, of course we pass through highways or asphalt roads, because asphalt roads are a very efficient means of transportation to facilitate everyone's travel. Often when driving on the highway in summer, of course we look ahead to the direction of the road. When we notice that the road looks like there is a puddle of water on it, or it can somehow get wet, as it gets closer, the effect disappears, this phenomenon is an optical phenomenon (Nanda, 2022)(Irawan, Ramadhan, Saktioto, Fitmawati, Hanto, et al., 2022).

An optical phenomenon is a phenomenon that occurs due to the interaction of light and medium with an unequal refractive index. This phenomenon causes the eye to see the shadow of an object that does not actually exist to become real. This optical phenomenon is like an illusion that convinces the eye that what we see is a real object, even though it is not real at all. That phenomenon is called a mirage.

Mirages are events that humans see on the surface of the earth, not only in desert places, but also in the oceans, at the poles and on the highways (Lovina, 2023)(Irawan, Ramadhan, & Azhar, 2022). The formation of the mirage is the result of the bending of light that occurs because it interacts with different temperatures and air densities (Anissa, 2020)(Ahmad et al., 2021). The light bend then reveals certain objects that are not actually on the scene. Thus, mirages are an illusion due to the refraction of light.

Under certain conditions, a mirage on the highway is an inferior type of mirage. An inferior mirage is an event caused by light being deflected and causing the light to seem to be reversed from its actual condition(Irawan, Azhar, & Ramadhan, 2022). This happens because of the refraction of light that interacts with different air temperatures and densities (Syaifudin, 2018). Hot asphalt makes the air on top of it hot, so there are two layers of hot air at the bottom and cold air at the top (Inaglory, 2022). The incoming rays propagate through hot air having a less dense density to cold air which has a very dense density so that the incoming rays are deflected or commonly called refraction.

How to Cite :

Rahmadani, P. et al. (2024). Transformation of Electronic Communication. *Journal of Science : Learning Process and Instructional Research (JoSLEPI)*, 2(2), 35-43

How could it be that during the hot day a puddle of water was seen on the highway, even though when approached there was not the slightest bit of water. Is this just an illusion? And how can this illusion happen? This article presents in its entirety the optical phenomenon of mirages on the road. Which includes a discussion of the meaning of optical mirage, types, examples, causes and dangers of the mirage phenomenon.

2 Research Methodology

The occurrence of this mirage includes theories that include the science of physics. The following are some of the causes of the optical phenomenon of mirage:

2.1 Light Refraction

Light refraction is the direction in which light propagates coming which is deflected due to propagation through 2 mediums of different densities. Refraction is divided into 2 types, namely:

- The incoming light propagates from a medium that has an untight density to a medium with a denser density, then the incoming light will be deflected closer towards the normal line.

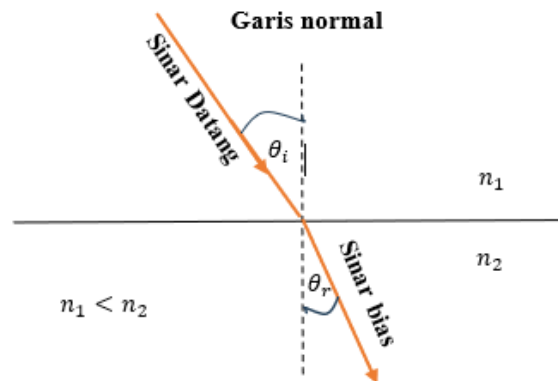


Figure 1 : Light refraction $n_1 < n_2$

- Light that propagates through a medium with a denser density towards a medium that has a non-dense density, then the incoming light will be deflected away from the normal line.

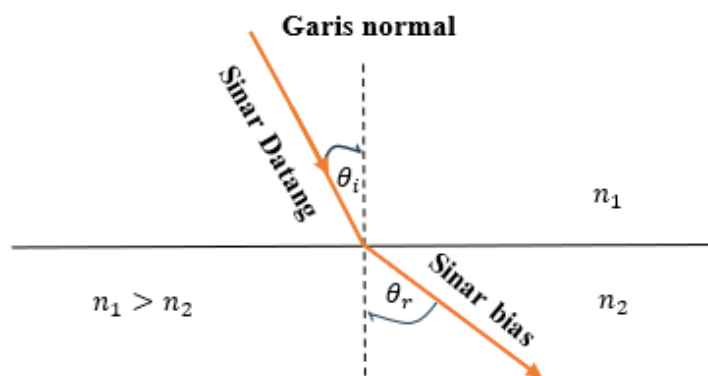


Figure 2 : Light Refraction $n_1 > n_2$

2.2 Snellius' Law

Snellius Law is one of the laws that discusses the refraction of light. This Snellius law is divided into two, namely:

- **The Law of Snellius I.** This law states that:
"sinar datang, sinar bias dan garis normal terletak dalam satu bidang datar"
- **The Law of Snellius II.** This law states that:
"perbandingan sinus sudut datang dan sinus sudut bias selalu konstan"

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2}$$

$$v = \lambda \cdot f$$

where:

v : Fast Propagation (m/s)

λ : Wavelength (m)

f : Frequency (Hz)

2.3 Bias Index (n)

The refractive index is the speed at which light travels through the medium. The refractive index of each medium is certainly not the same. This refractive index is the difference between the speed of light propagating in a vacuum and the speed at which light travels through the medium. We know that the speed of light propagating through a vacuum is $3,00 \times 10^8 m/s$

2.4 Perfect Reflection

Perfect reflection is an event where the incoming light is fully reflected without being refracted in the slightest. Perfect reflection can only occur when a critical angle is formed. The critical angle is the angle of refraction that forms an angle of $90(\theta_c)^\circ$ or the refractive beam is right adjacent to the boundary line of the two mediums.

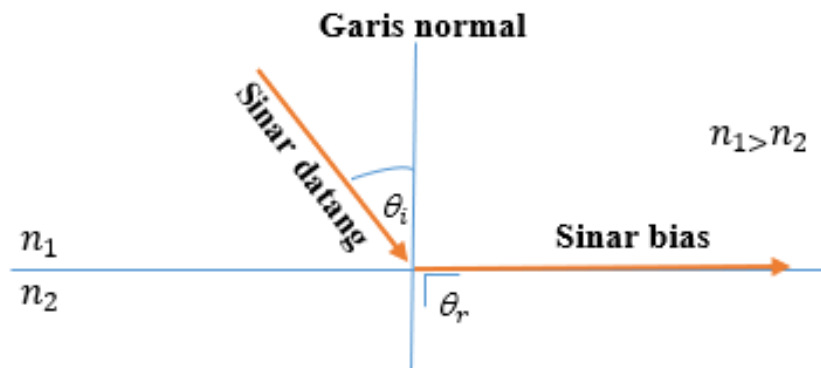


Figure 3 Critical Angle

3 Results and Discussion

3.1 Definition of Mirage

Mirage is an optical illusion phenomenon that often occurs naturally during hot weather (Pratama, Reza Y A. Koesyanto, 2020)(AMERY, 2020). Variables such as the path of light particles, the curvature of the earth, and the temperature of the air can produce images that the eye believes to be real. Mirage is a false shadow such as puddle of water on a highway or asphalt that occurs due to the deflection of light rays (light refraction) (Soetopo, 2010)(Irawan, Ramadhan, Saktioto, Fitmawati, Widiyatmoko, et al., 2022).

Light will be refracted if the incoming light is deflected when the incoming light propagates on a medium with different levels of density. This refraction will cause a change in the rate of light due to the difference in the refractive index of the two mediums. The difference in the rate of light between the two different mediums results in the refraction of light.

Light generally travels straight, but due to the presence of layers of air that have different densities, the air becomes like a mirror that can deflect light. If the lower layer of air is hotter, then the incoming rays will be refracted in a low position such as the ground surface, while if the lower layer is cooler, the incoming light rays are deflected/refracted in a different direction with a higher position.

3.2 Types of Mirages

3.2.1 Inferior Mirage

This phenomenon is similar to water standing on the asphalt surface. This is due to the hot asphalt which creates a layer of hot air on the asphalt so that it looks like a puddle of water which is in fact an inverted condition due to perfect reflection. When the air becomes hot, it will cause the density to be less dense than cold air. When the incoming rays propagate through the hot air and through the cool air, the incoming rays will be refracted.

The mirage looks like an object reflected in the water because the light of the object propagating to the ground is deflected up to the eye and forms a double shadow. This phenomenon is always visible on the asphalt when the weather is sunny and hot, and it always looks like water is standing on the asphalt (Greenler, 1986).

3.2.2 Superior Mirage

This phenomenon is widely seen at the poles and in the sea, because the air temperature around the sea and poles is cooler than the surrounding air temperature, so that the incoming rays that pass through the hot air to the cool air form a shadow that occurs right above the original object.

This mirage is right on top of the original object, it can be in a perpendicular shadow state or an inverted shadow state. When the mirage appears higher in the sky than the object.

3.2.3 Neutral Mirage

This mirage occurs in a vertical line, so the shadow of the created object is next to the original object. The lateral phenomenon occurs when the wall is less tight than the air around it. This statement is in accordance with Snellius Law II which states that light rays passing through a dense medium to a sparse medium will be deflected away from the normal line (Gosudareva, 2011).

3.3 Examples of Optical Mirages

There are many examples of optical mirages. The following are the events of the optical mirage, namely:

3.3.1 Examples on inferior Mirages

In an inferior mirage, the air temperature above it is lower than the temperature on the ground and asphalt road surface. This phenomenon occurs when light comes through a layer of cool air to a layer of hot air underneath. The phenomenon is shaped like a puddle of water that appears to be visible on hot surfaces.



Figure 4 : Inferior Mirage

3.3.2 Example on Superior Mirage

In superior mirages, it occurs because rays come through a layer of hot air to a layer of cooler air underneath. The phenomenon is like when a fisherman catches fish in the middle of the sea, then sees a boat that looks like it is floating or flying.



Figure 5 : Superior Mirage

3.4 Causes of Optical Mirage

During the hot afternoon, asphalt roads exposed to sunlight cause asphalt roads to become very hot. Because asphalt roads have a very high temperature, the air near the top of the asphalt becomes very hot so that the density is not tight, we say a layer of hot air (Pettigrew, 2003). Meanwhile, the air layer above the hot air has a cooler temperature than the hot air temperature so that it has a close density, we say the cold air layer (Ezokanzo, Tethy. Annisha, 2019). Hot air has a more tense density because if the air temperature is hot, the particles in the air will stretch and move away so that the density will decrease (Irawan, Ramadhan, Saktioto, & Marwin, 2022).

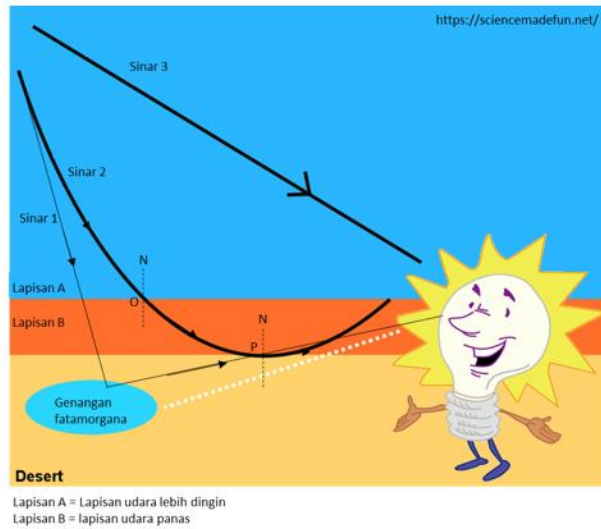


Figure 6 : The process of occurrence of mirages

In light refraction, if the light rays come propagating through a low-density medium towards a high-density medium, they will be deflected away from the normal line (Erniwati, 2018)(Nasution, 2018). In the image above, the light beam travels through the cold air to the hot air (Lajnah, 2016), so that the refraction of the incoming rays 1 away from the normal line.

Then ray 2 propagates with a larger angle of incoming rays, making the rays deflected right into the boundary plane of the two mediums. The angle is called the critical angle which results in a 90° angle (Idris, Tjoet Nia Usmawanda, 2018). After that beam 3 propagates at a larger angle than beam 2, so that the beam is only reflected. The more rays 3 the more rays are reflected perfectly (Britannica, 2024).

3.5 Conditions for the Occurrence of Optical Mirages

3.5.1 Light Refraction

The process of the mirage phenomenon cannot be separated from the different refractive indices of both hot and cold media (Hairunisa, 2017). The refractive index of cold air is greater than that of hot air. This is because when the air is hot, all particles in the air will stretch, causing light refraction that causes light to be reflected.

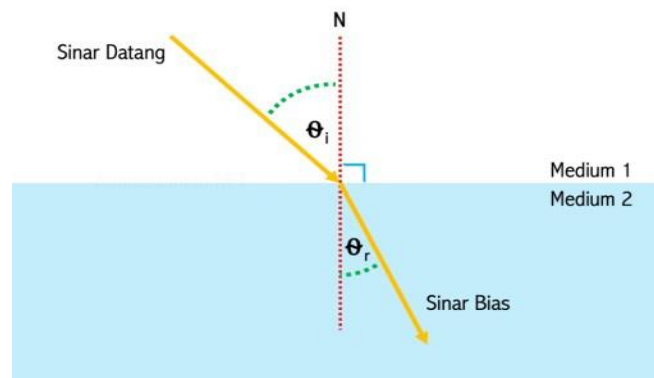


Figure 7 : Light Refraction

3.5.2 Total Bounce (Perfect)

Perfect reflection occurs when the refracted beam forms a critical angle (the exact refractive angle is 90°). As explained earlier, light light propagating the interface between second media with different densities will be deflected. Under certain conditions, All rays propagating an interface can be fully reflected without the slightest distortion, Although the second medium is transparent, as shown in the following picture:

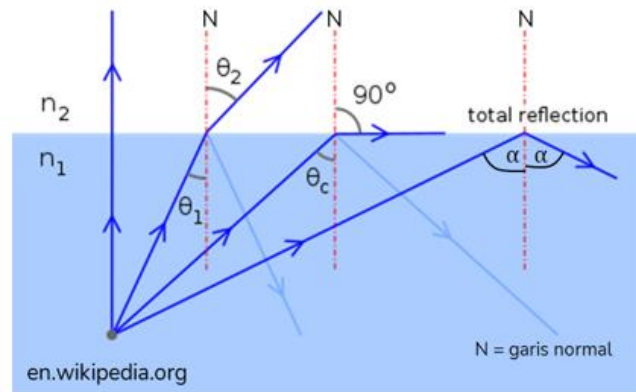


Figure 8 : Total Bounce (perfect)

This image shows the perfect reflection process taking place. A beam of light emitted from a light beam source P to media one (n_1 refractive index). The beam hits the surface interface of the two media (refractive index n_2) ($n_1 > n_2$). For example, media one is water and media two is air. In accordance with Snellius' law (Febrieliyanti, F., Harmadi, H., Dahlan, D., & Rilda, 2019) that is:

$$\sin r = \frac{n_1}{n_2} \sin i$$

So that when the incoming light propagates through a medium that has a large refractive index towards a medium that has a small refractive index, the incoming light rays will be deflected away from the normal line. The refractive rays are refracted right at the boundary line of the two mediums so that the refractive angle forms an angle of 90° which is called the critical angle.

3.6 Advantages and Disadvantages of the Optical Mirage Phenomenon

3.6.1 Excess

The mirage phenomenon is a natural phenomenon. By understanding this phenomenon, we also know how great the power of God Almighty is to create it. We can use the mirage phenomenon as a medium for self-development (in the context of knowledge).

3.6.2 Deficiency

This mirage phenomenon only occurs when the weather is summer, optical mirages are seen when the sun is hot interacting with different layers of air, this can make drivers passing by the road unable to see the road clearly and potentially accidents. So when this phenomenon occurs, we must be careful when driving, because this optical phenomenon is a natural phenomenon, not just an illusion, when we pay attention to the road and the closer we get to it, the effect will disappear.

4 Conclusion

The mirage phenomenon is an optical illusion due to sunlight being affected by the difference in air temperature on asphalt roads. This incident looks like a puddle of water on the road. There are three types

of mirages, namely inferior, superior, and lateral. The optical phenomenon of mirages on the highway is an example of an inferior type of mirage. The refraction of light due to the difference in the refractive index of the medium and the total reflection are the conditions for the occurrence of a mirage. The advantage of mirage is that we become amazed by the power of God Almighty in creating His creation, so this brings us closer to our belief in the Creator. There is also a drawback of mirages is that accidents occur and make every driver worried if they drive when the sun is hot.

5 Acknowledgement

We would like to thank the Department of Physics Education, FKIP, Riau University.

Reference

- Ahmad, N., Putra, P. D. A., & Wahyuni, S. (2021). Analisis Produksi Video Pembelajaran Pada Tugas Proyek Mata Kuliah Cahaya Dan Penglihatan Tema Fenomena Optik. *Education Journal: Journal Educational Research and Development*, 5(2), 203–214. <https://doi.org/10.31537/ej.v5i2.516>
- AMERY, F. (2020). ‘An attempt to trace illusions to their physical causes’: atmospheric mirages and the performance of their demystification in the 1820s and 1830s. *The British Journal for the History of Science*, 53(4), 443–467. <https://doi.org/10.1017/S0007087420000369>
- Anissa. (2020). *GELOMBANG BUNYI DAN CAHAYA FISIKA KELAS XI*. Direktorat SMA, Direktorat Jenderal PAUD, DIKDAS dan DIKMEN.
- Britannica, T. E. of E. (2024). *mirage*. Encyclopedia Britannica.
- Erniwati, T. O. (2018). *Ensiklopedia Cahaya*. K-Media.
- Ezokanzo, Tethy. Annisha, W. (2019). *Fenomena Alam Unik*. Bhuana ilmu populer.
- Febrielyanti, F., Harmadi, H., Dahlan, D., & Rilda, Y. (2019). Rancang Bangun Sensor Kelembaman Udara menggunakan Plastic Optical Fiber (POF) dengan cladding TiO₂-SiO₂ dan Data Transmisi. *Jurnal Fisika Dan Aplikasinya*, 15(1), 29–33.
- Gosudareva, E. Y. (2011). *MIRAGES*.
- Greenler, R. G. (1986). Laboratory Simulation of Inferior and Superior Mirages. *Topical Meeting on Meteorological Optics*, ThB2. <https://doi.org/10.1364/MO.1986.ThB2>
- Hairunisa. (2017). Penerapan model pembelajaran student facilitator and explaining dan student team achievement divisions terhadap kemampuan komunikasi sains dan berpikir kritis siswa. *Digital Library LAIN Palangka Raya*.
- Idris, Tjoet Nia Usmawanda, N. (2018). Pengaruh Suhu dan Tekanan Udara Lingkungan Terhadap Visibilitas Fatamorgana di Landasan Pacu (Runway) Bandara Sultan Iskandar Muda, Blang Bintang, Aceh Besar, Aceh, Indonesia. *Risalah Fisika*, 2(2), 35–42. <https://doi.org/10.35895/rf.v2i2.108>
- Inaglory, B. (2022). *Optical Phenomena*. UBC ATSC 113.
- Irawan, D., Azhar, A., & Ramadhan, K. (2022). High-Performance Compensation Dispersion with Apodization Chirped Fiber Bragg Grating for Fiber Communication System. *Jurnal Penelitian Pendidikan IPA*, 8(2), 992–999. <https://doi.org/10.29303/jppipa.v8i2.1521>
- Irawan, D., Ramadhan, K., & Azhar, A. (2022). Design of PCF-SPR for Early Detection of Skin Cancer Infected Cells. *Jurnal Penelitian Pendidikan IPA*, 8(5), 2293–2298. <https://doi.org/10.29303/jppipa.v8i5.2120>
- Irawan, D., Ramadhan, K., Saktioto, Fitmawati, Hanto, D., & Widyatmoko, B. (2022). Hexagonal two layers-photonics crystal fiber based on surface plasmon resonance with gold coating biosensor easy to fabricate. *Indonesian Journal of Electrical Engineering and Computer Science*, 28(1), 146–154. <https://doi.org/10.11591/ijeecs.v28i1.pp146-154>
- Irawan, D., Ramadhan, K., Saktioto, Fitmawati, Widyatmoko, B., & Hanto, D. (2022). High-Performance of Star-Photonics Crystal Fiber Based on Surface Plasmon Resonance Sensor. *Indian Journal of Pure and Applied Physics*, 60(9), 727–733. <https://doi.org/10.56042/ijpap.v60i9.64411>
- Irawan, D., Ramadhan, K., Saktioto, & Marwin, A. (2022). Performance comparison of TOPAS chirped fiber Bragg grating sensor with Tanh and Gaussian apodization. *Indonesian Journal of Electrical Engineering and Computer Science*, 26(3), 1477–1485. <https://doi.org/10.11591/ijeecs.v26.i3.pp1477-1485>
- Lajnah, P. M. A.-Q. (2016). *Tafsir Ilmi: Cahaya Dalam Perspektif Al-Qur'an Dan Sains / Lajnah Pentashihan Mushaf AL-Quran*. Lajnah Pentashihan Mushaf Al-Qur'an.
- Lovina, R. (2023). Kajian Pembangunan Infrastruktur (Jalan, Jaringan Listrik, Telekomunikasi) Yang Disinergikan Dengan Pembangunan Jalur Hijau Di Kota Tanjungpinang. *Jurnal Archipelago*, 02(2), 181–193.
- Nanda, I. G. R. A. G. K. S. (2022). ANALISIS FAKTOR HUMAN ERROR, HEWAN, CUACA DAN RAMBU-RAMBU LALU LINTAS TERHADAP TERJADINYA KECELAKAAN LALU-LINTAS PADA JALAN RAYA DENPASAR-GILIMANUK KABUPATEN JEMBRANA BALI. *EBISMEN Journal Ekonomi, Bisnis Dan Manajemen*, 1(1), 1–10.

- Nasution, T. A. K. (2018). Pengaruh Metode Demonstrasi Terhadap Hasil Belajar Siswa Pada Mata Pelajaran IPA Sub Bahasan Cahaya Dan Sifat-Sifatnya Di Kelas V Min Medan Tembung Tahun Pelajaran 2017/2018. (*Doctoral Dissertation, Universitas Islam Negeri Sumatera Utara*).
- Pettigrew, J. D. (2003). The Min Min light and the Fata Morgana An optical account of a mysterious Australian phenomenon. *Clinical and Experimental Optometry*, 86(2), 109–120. <https://doi.org/10.1111/j.1444-0938.2003.tb03069.x>
- Pratama, Reza Y A. Koesyanto, H. (2020). Kejadian Kecelakaan pada Pengemudi Ojek Online. *HIGELA Journal of Public Health Research and Development*, 4(1), 13–24. <https://doi.org/https://doi.org/10.15294/higeia.v4iSpecial%201.34997>
- Soetopo. (2010). *Kuark - Adaptasi, Konservasi, dan Kemagnetan: Komik Sains Kuark Tahun 6 Edisi 10 Level 3* (Soetopo (ed.)). PT Kuark Internasional.
- Syaifudin, M. (2018). Pembelajaran fisika menggunakan pendekatan interactive conceptual instruction (ici) terhadap kreativitas siswa dan hasil belajar pada materi indra penglihatan dan alat optik kelas VIII semester II MTS ISLAMİYAH Palangka Raya tahun ajaran 2018/2019. *Digital Library LAIN Palangka Raya*.