INVESTIGATION OF ELECTROMAGNETIC WAVE PROPAGATION IN CB RADIO WITH ELEMENTARY SCHOOL STUDENTS: A “SUPER BOWL” MYSTERY

KITAGAWA, Alexandre Takio[1]; DE OLIVEIRA, Ana Carolina Hemmer; BRANDL, Emanuella; MAFFEZZOLLI, Anni Carolini; [2]

[1]Departament of Education of Indaial, Brazil and Amateur radio - PU5KTA, [2]Professora Anna Alves Dias Public Middle School, [3]Professora Úrsula Kroeger Public Middle School

Abstract

This study describes an experiment conducted by middle school students in Santa Catarina, Brazil, using CB radios to learn about electromagnetic waves. The students, using standard 4 watt CB radios on channel 6 (27.025 MHz AM), received a signal identified as originating from the USA and related to the “Super Bowl” broadcast. Despite the low power, the signal traveled approximately 7,850 km, a distance explained by HF wave propagation via the ionosphere. The ionosphere reflects radio waves, enabling long-distance communication. The students observed signal variations consistent with ionospheric electron density fluctuations, demonstrating the ionosphere’s influence. This hands-on experience provided the students with a practical understanding of radio communication and the role of the ionosphere in wave propagation.

Introduction

The Citizen’s Band Radio Service (CB Radio), as defined by the United States Code of Federal Regulations (CFR, Title 47, Part 95), is a two-way voice communication service operating in the 27 MHz band, divided into 40 channels with a power limit of 4 Watts (NELSON, 2023). Classified as High Frequency (HF), CB radio shares the spectrum with other services (SILVER, 2021), and in Brazil, the CB Radio Service offers similar functionalities with simplified registration (ANATEL, 2015).

Method/Experiment

Motivated by its accessibility and low cost of equipment, elementary school students in Santa Catarina (-26.8668712, -49.2317786) conducted an experiment during lessons on electromagnetic waves.

Figure 01: Location of the school where the reception tests were conducted. (Modified from Google maps and wikipedia)

Using Aquarius RP40 and Uniden PRO401HH CB radios, students received signals on channel 06 (27.025 MHz) in Amplitude Modulation (AM).

Figure 02: Equipment used in the reception test. Aquarius RP40 and Uniden PRO401HH (The authors)

Data and Analysis

Identified as originating from the USA and related to the “Super Bowl” broadcast (POLSKIFM, 2024) through analysis of message content, it was found that the signal traveled approximately 7,850 km from its origin to the reception location (RADIOCONFERENCE, 2011).

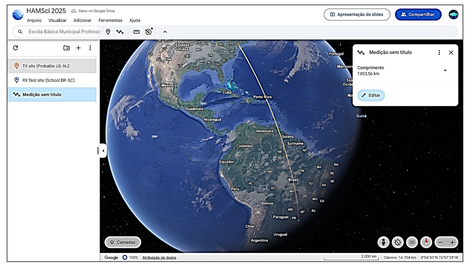

Figure 03: Distance between the two CB radio stations (Google Earth)

This distance was estimated using geolocation tools and information from potential broadcasters found online, demonstrating the propagation of HF waves through the ionosphere (BRUSCATO, 2011; BRUSCATO & MORS, 2014). This region of the upper atmosphere reflects radio waves back to Earth, enabling long-distance communication through multiple “skips” between the ionospheric layers and the Earth’s surface. The observed variation in the received signal intensity, consistent with fluctuations in ionospheric electron density, highlights the influence of the ionosphere on signal propagation (HUNSUCKER; HARGREAVES, 2007).

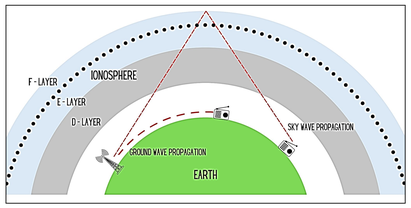

Figure 04: Interaction of electromagnetic waves at the studied frequency with the Ionosphere. (Kitagawa et al., 2024)

Figure 05: Reception of signals on CB Radio.

Conclusion

Although long-distance reception may raise questions about transmission power, antennas, and among other factors, this study emphasizes the role of the ionosphere, providing students with hands-on experience with radio communication equipment, deepening their understanding of electromagnetic waves through the ionosphere layer, and inspiring scientific inquiry.

References

ANATEL - Agência Nacional de Telecomunicações. Rádio do Cidadão. Serviço Rádio do Cidadão (PX), 2015.

BRUSCATO, G. C. O ensino de física através das atividades práticas realizadas na instalação, operação e manutenção de uma estação radioamadora. 2011. 177 p. Dissertação de mestrado (Programa de Pós-graduação em Ensino de Física) Instituto de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2011.

BRUSCATO, Gentil César; MORS, Paulo Machado. Ensinando física através do radioamadorismo. Rev. Bras. Ensino Fís., São Paulo, v. 36, n. 1, p. 1-8, Mar. 2014.

Federal Communications Commission. 47 CFR 95.903 Definitions, CBRS.

HUNSUCKER, Robert D.; HARGREAVES, John Keith. The high-latitude ionosphere and its effects on radio propagation. Cambridge University Press, 2007.

KITAGAWA, Alexandre Takio. Use of the Short Wave Radio to prove the ionosphere with students from a public school in Brazil. HamSCI Workshop 2021. HamSCI, Scranton, PA (Virtual), 2021.

NELSON, Caleb. CB Radio For Preppers: a how-to guide to get on the air before the apocalypse. eBook Kindle, 2023.

POLSKIFM. Twoje Awaryjne Źródło Informacji Raddy RF757: Kompaktowe Radio, Wielkie Możliwości. Polski FM, 2024.

RADIOCONFERENCE. Big power on channel 6. Radioconference.com - CB Radio Forum, 2011.

SILVER, H. Ward. Ham Radio for Dummies. John Wiley & Sons, 2021.

Acknowledgements

We are deeply grateful to HamSci for this valuable opportunity to participate. We also want to thank the Department of Education of Indaial for their crucial support and the inspiring directors and teachers for their encouragement and dedication. Your combined efforts made this a truly meaningful experience.

alexandre.takio@indaial.edu.sc.gov.br