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Unraveling Mystique: Long-Delay Echoes; Anomalous Propagation of Radar Signals under the Influence of Unidentified Anomalous Phenomena

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Abstract

This research study represents an ongoing research effort on Unidentified Anomalous Phenomena (UAP) with a focus on anomalous propagation of radar echo returns, mirroring established theoretical constructs of gravitational effects on light, which occur at higher frequencies and shorter wavelengths within the Electromagnetic Spectrum. These influences are also illustrated through other technologies, including Light Detection and Ranging (LIDAR) and the chromatic effects captured by hyperspectral cameras. This research addresses the complexities of interpreting unusual propagation patterns, such as Long Delay Echoes (LDE) and unexpected Field Echoes (UFE), which disrupt the anticipated propagation and echo protocols, thereby challenging our understanding and comprehension of radio transmission norms that may be influenced by a form of quantum entanglement. The paper posits a significant and largely unexamined correlation between these phenomena in the context of UAP activity, highlighting the urgent need for further research and innovative strategies in navigation technology and environmental monitoring to investigate these potential occurrences, which have remained enigmatic for nearly a century. Radar signals are vulnerable to intricate dynamics that can lead to Unusual Field Echoes (UFE), resulting in emergent anomalies, such as Multiple echo returns and LDEs. This study employed a 3-centimeter marine-based X-band radar operating in two scan geometries and a portable short-range millimeter-wave Doppler radar system. An analysis of these radar echoes over a two-year study identified signal propagation that deviated from navigational standards on Plan Position Indicators (PPI). This paper explores and investigates the potential impacts of UAP on radar transmission routes. Examining these complexities makes a case for an enhanced understanding of the interactions between established technological factors and elusive aerial phenomena.

Keywords

Radio Detection and Ranging (RADAR), Light Detection and Ranging (LIDAR), Long-Delay-Echo (LDE), Millimeter-Wave (MW), Radar, Unidentified Aerial Phenomena (UAP), Anomalous Propagation (AP), Universal Field echoes (UFE), Plan Position Indicator (PPI)

1. Introduction

In July 2022, Nightcrawler's mobile research laboratory was deployed along Long Island's coast to investigate Unidentified Anomalous Phenomena (UAP) activity over a coastal location for a Phase 1 study. This sophisticated research platform enabled the researchers to conduct maritime research studies through instrumented surveillance and reconnaissance operations, providing unprecedented capabilities to observe activities in and around marine environments. The Nightcrawler platform utilized cutting-edge Hyperspectral optical systems and Marine radar. In 2023, Phase 2 of the project meant another upgrade of these systems, including integrated Hyperspectral camera and Binary sensors for UV and SWIR. In 2024, Phase 3, camera suits were again upgraded and installed in portable sensor PODs with integrated Millimeter-Wave Radar, which gives us Quad-view visuals of four video spectrums, from Ultraviolet (UV) to short-wave infrared (SWIR). Nightcrawler also employed LIDAR to complement our RF radar systems. Together with environmental sensors and millimeter-wave radar, we were confident that we would cover a large portion of the electromagnetic spectrum. Maritime microwave and millimeter-wave radar technologies were employed to study unusual radar anomalies that produced long-delayed echoes and Racon-like interference patterns. The complexities of radar signal propagation create various challenges, leading to anomalous propagation (AP) scenarios that can make it difficult to interpret radar data clearly.

Technological advancements in radar systems have transformed maritime surveillance, significantly augmenting our ability to monitor ocean activities and improve navigation safety. However, the intricate nature of radar signal propagation can lead to misleading AP effects that obscure our understanding of maritime conditions. This study delves into these unusual observations, extensive echoes, and unexpected signal returns—that might be affected by unidentified aerial phenomena when observed being particularly close to large vessels. Using large sea vessels as a reference offers significantly greater return echoes than smaller craft. Over the course of an 18-month investigation, seven specific and well-documented radar anomalies were recorded, where a larger known target was accompanied by at least one unidentified target. Radar Propagation Anomalies are believed to be behind the UFE and LDE presented on the PPI radar interface (Editorial Staff, 2023) [1].

This study explores the characteristics of these AP phenomena, including perennial occurrences like Long Delay Echoes (LDEs), long radar target streaks, and Racon-like responses. It suggests that dynamic changes were imposed over the transmitted radio signal, altering characteristic norms, such as travel velocity. This unusual phenomenon was much more prevalent during the occurrence of a smaller unidentified target within the Field of View of a 5.7-degree rotational Arc.

2. Research Study

2.1. Site Selection

A coastal Long Island study was chosen based in part on anecdotal historical records of observations, reflecting the more significant number of reports near the coast (ODNI Staff, 2024) [2] as described by the U.S. Naval fleet' and pilot incursions off the Pacific and Atlantic seaboard of the United States. These incursions occurred as close as 10 Nautical miles (NM) from the coast. This persistence in phenomenology, as reported by these trained observers, who qualify as expert witnesses under Federal Rule 702, offered us a promising setting for field research. Based on these premises, a ten-month Phase-1 field study, including two months of data review, analysis, and plans for Phase-2 study, would ensue. Long Island's geographic location is well within the eastern regional perimeter (Long Island extent, 120 miles).

The geographic regions chosen were Robert Moses State Park on the southern coast of Fire Island National Seashore, Cedar Beach on Long Island's North Shore, with access to the Long Island Sound, and The Great South Bay, which is Long Island's largest body of water inland, separating Fire Island from Long Island's South shore. These locations are referenced in **Figure 1**.

Figure 1. The site location.

We established the field study's geographic perimeter and baseline parameters similar to a typical or standard Forensic environmental scene assessment. This included the carefully selected site for secured and controlled conditions. We obtained a scientific field research permit from the state Parks Department to have unrestrained access and control over the area/region. For instance, park security restricted human activity, low light pollution, and reduced human-caused air traffic at specific timeframes, which offered us almost ideal research conditions. The area was chosen based on retrospective historical data of high UAP reports, the 2014 USN F/A-18 Super Hornet pilot reports, based on the USS Theodore Roosevelt, and pilot admissions through personal conversations. Area dimensions were identified and documented through scene surveys, GPS mapping, and laser range finders. Primary and secondary surveys were accomplished using instrumented means, such as radar scans, M/E-O (Multi-spectral Electro-optical) devices, and electromagnetic measurements. All baseline data was recorded, examined, processed, and preserved on the scene for internal controls over the evidentiary data.

2.2. The Phase-2 Initiative

Under the Phase II initiative, we expanded the geographic coastal range of the research study further east to include Camp Hero in Montauk Point. New instrument purchases and accessories further developed new, enhanced hyperspectral equipment with greater sensitivity and bandwidths. This also included breakthroughs in integrated technological radar designs to increase our hyperspectral observations and measurement capabilities.

The radar system technologies employed included Furuno models 1815 (Horizontal Scanning) and 1715 (Vertical Scanning) marine-based X-Band radar operating in the 3 cm band (9.4 GHz) and a Portable Millimeter-Wave Doppler/Ranging Radar with operating frequencies of 24 GHz and 36 GHz. This also included Light Detection and Ranging (LIDAR), which uses the shorter wavelength Infrared (IR) as a secondary detection system. Using multiple radar technologies deepens our insight into maritime environments and signal behavior, which may differ by technology. When all systems indicate similar unexpected measurement data on the radar display (the Plan Position Indicator), it triggers a need for further examination.

2.3. Anomalous Propagation Patterns: Understanding UFE and LDE

Over a two-year study, radar observations revealed that five percent of the radar data contained unusual propagation features characterized by streaks or distortion echoes unrelated to familiar maritime targets. These anomalies resembled signals typically associated with Ramark and Racon devices. Racon (Radar Control) and Ramark (Radar Marker) are older Radar Navigation Aids (See **Figure 2**). They are examples of Responder-type beacons triggered by a ship's radar pulses. When the radar pulse strikes the antenna receiver, Racon sends out video signals (characteristics/I.D.). The Ramark is a Responder that transmits continuously or at intervals. Therefore, the transmitting ship's radar will receive signals from the Ramark when the ship's scanner is pointing toward the beacon. Ramark beacons are no longer employed as a Navigation aid near U.S. shores. Modern beacons called Transponders provide positive identification and other relevant data.

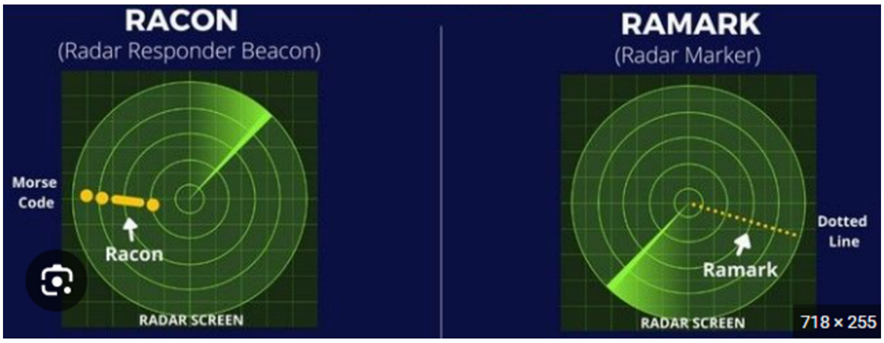


Figure 2. The two images represent radar Responder beacons, which, once triggered by ship radar, broadcast a directional pattern on the radar PPI of a hazard or buoy (Ramark-International Directory, 2024) [3].

When triggered by a ship's radar, the Racon Responder emits a characteristic signal. The signal may be emitted on the same frequency as the triggering radar, which is automatically superimposed on the ship's radar display. The signal may be emitted on a separate frequency, in which case, to receive the signal, the ship's radar receiver must be capable of being tuned to the beacon frequency, or a particular receiver must be used. These tools provide ships with coded directions about landmarks and vital coastal positions. These microwave devices relay information back to the ship whenever the ship's radar emits a pulse, reflecting the identity, location, and function of the Racon in Morse code (Tideland staff, 2024) [4]. Racons are utilized to pinpoint numerous items, including buoys, lighthouses, coastlines, navigable channels under bridges, offshore oil structures, and ecologically sensitive sites like coral reefs Navigation Center Staff, 2019) [5].

A Racon signal can be the same or a different frequency than the radar, which means the ship's radar receiver must be tuned accordingly, or a specific receiver must be used. When signal echo anomalies arise, they can appear like Racon-like Responder emissions. Our analysis indicates that the Racon-like appearance of the broken linear tracks does not coincide with Racon Transponder tracks. The transmitted signals are likely spurious echoes over a single 360-degree sweep of the Scanner (antenna). Defined UFE echoes can give multiple echo linear trace vectors, as shown in **Figure 3**.

However, undefined UFE echoes with multiple trace vectors scatter around the PPI (See **Figure 4**) are anomalous Propagation of possibly a Responder or S-Band Radar Ping signals from another ship within a 4-mile radius. Another ship would be easy to identify. These kinds of signals are rare.

LDE echoes are reflected back with echo trails exceeding the typical trace radius of a target based on its size. These echoes have extended delays, leading to long trails that occur after significant sweep intervals. Another possible explanation is a directional distortion of the micro or milli-wave hitting the sea over multiple

Scanner rotations, just as the Racon-like pattern anomaly, pre-echo interference, and post-echo delays may be associated with gravitational distortion or stem from gravitational lensing.

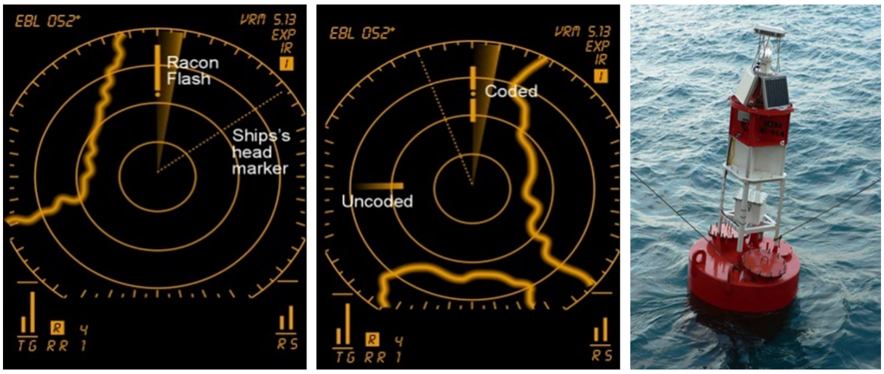


Figure 3. UFE echoes on a vertical scanning radar, and multiple reflected echoes are shown.

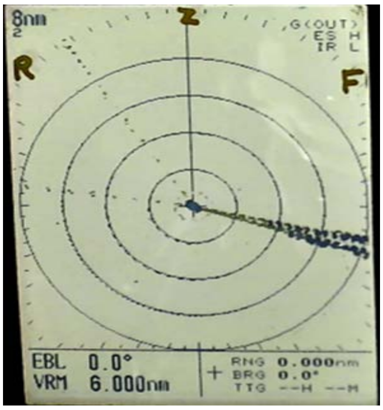


Figure 4. The racon signal displayed on the PPI left shows a radar transponder emitting a characteristic signal when triggered by another ship's radar (Gyyan Staff, 2020) [6].

Based on engineering feedback from Furuno's engineering department, these kinds of interference patterns are not typically seen as a result of most common environmental factors, such as atmospheric influences. Complex interference patterns like this could suggest a possible paraphysical role of UAP in altering signal behavior, especially when no objects are within the radar field range. Despite these anomalies being relatively rare, the Racon Transponder-like pattern before or after a known large target (see Figure 4) and the LDE of a known target that may initially present as a typical trace but suddenly stretch along a range marking, extending as much as one, two, or more quadrants (90 to 360 degrees), linking these AP events potentially to the presence of UAP.

The phenomenon known as Long Delay Echoes (LDEs) has been intermittently recorded over the last several decades. Characterized by echoes returning seconds to minutes after the original signal, the nature of LDEs has traditionally invited a variety of theories, yet none fully explain the phenomenon. Their documented presence dates back to the 1920s, prompting progressive theories around radar signal distortions, addressing terrestrial interference like ground clutter or super-refraction, and possibly indicating undetected foreign influences interacting with radar operations. Occasionally, phantom anomalies and patterns emerge. We don't think this is the case here. Our analysis suggests that transmitted pulsed signals are delayed and occur after significant intervals following transmission. They may not just stem from atmospheric disturbances but also hint at the paraphysical presence of UAP affecting signal behavior.

Despite these relatively infrequent anomalies, a pattern correlating AP occurrences with likely unidentified objects within the radar's scanning domain has been discerned. Central to this context lies a phenomenon labeled Long Delay Echoes (LDEs), identified intermittently over the past several decades. The characteristics of LDEs, which manifest in echoes echoing back from brief seconds to prolonged intervals post-signal transmission, have warranted diverse theoretical explanations over time. None, however, furnish a consummate rationale. Historical observations reach back to the 1920s, inspiring evolved interpretations of radar signal distortions that extend beyond terrestrial interferences like ground clutter or super-refraction and opening dialogues towards examining conflicting agents potentially nesting undetected, interlacing with operational paradigms.

2.4. Understanding Long Delay Echoes

The history of Long Delayed Echoes (LDEs) dates back to the late 1920s, with the first reported observations made by amateur radio operator Jørgen Hals in Norway, who detected unexpected, significantly delayed radio echoes from a Dutch transmitting station in Eindhoven, Netherlands, physicist Balthasar van der Pol later investigated these echoes. Still, their origin remained largely unexplained due to their sporadic nature and varying time delays. Long Delay Echoes (LDE) have perplexed radio and radar users for decades. LDEs manifest as signals returning seconds after their initial emission, and though various interpretations exist—primarily concerning the entrapment of waves within ionization ducts—they remain an enigma. Most notably, radio frequencies below 4 MHz traverse through ionized layers, potentially spiraling their journey up to the contrabass layers of our atmosphere before reflecting back (Holm, 2021) [7].

Although this phenomenon's frequency threshold is limited to frequencies less than 10-megahertz (Mhz), the implications of this under-performance mechanism extend to modern radar technologies with frequencies extending beyond 300 Mhz (UHF Band) to greater than 26 GHz (K, KA Band) Millimeter Band of wavelengths. Two prevalent marine radar bands, S and X-Band, have center Frequencies of 3.1 Ghz and 9.4 GHz, respectively. Three gigahertz, encompassing X-band radars functioning at a frequency of 9.4 GHz and Millimeter-Wave radar at magnitudes even higher, 36 GHZ, which do not predominantly constitute possible cases for LDE phenomena due to their amplitude exclusion from ionization constraints. Nevertheless, understanding such transition realms fosters curiosity about UAP's influence on signal propagation.

LDE, defined as echoes received from a fraction of a second to several seconds after the initial transmission of a radio signal, have been intermittently observed for over 50 years. Although various explanations have been put forward over time, none have fully resolved the phenomenon. Currently, the following models are suggested to explain LDE: Radio waves with frequencies below approximately 4 MHz may become entrapped in ionization ducts aligned with magnetic fields, specifically within regions with L values under about 4. Once these waves are confined, they can travel to the opposite hemisphere of the Earth, where they are reflected back from the upper ionosphere. Subsequently, they can return along the duct, exit it, and propagate to the receiver, causing delays of up to 0.4 seconds. This mechanism likely accounts for the majority of LDE encountered at frequencies below 4 MHz, with estimated delays ranging from 1 to 2 seconds (Muldrew, D.B., 1979) [8].

3. Instrumentation: Nightcrawler Radar System Specifications

3.1. X-Band Marine Radar (3 cm Wavelength)

The study utilized two X-Band marine-based radar systems operating at the 9.4 GHz Center Frequency and two portable Millimeter-Wave Doppler/Range Radar Sensors with operating frequencies of 24 GHz and 36 GHz. For further synthesis and understanding across spans within the text, we lend contextual reference here to describe the equipment Payload (See **Figure 5**).

Figure 5. X-band marine radars (3 cm wavelength).

Furuno 1815 X-Band Radar
(3 cm):

Furuno 1815 Marine Radar: Peak Output Power 4 kW, Antenna Type 488 mm (19" radome), Operating Frequency, 9410 MHz ± 30 MHz, Beam Width (Horizontal) 5.2˚, Beam Width (Vertical) 25˚, Range Scales 0.0625 - 36 NM, Minimum Range Limit 25 meter, and antenna rotation Speed 24 rpm.

Furuno 1715 X-Band Radar
(3 cm)

Peak Output Power 2.2 kW, Antenna Type (19" radome), Operating Frequency 9410 MHz ± 30 MHz, Beam Width (Horizontal) 5.2˚, Beam Width (Vertical) 25˚, Range Scales 0.0625 - 24 NM, and Minimum Range Limit 25 meter.

3.2. Millimeter-Wave (MW) Radar (8 mm Wavelength)

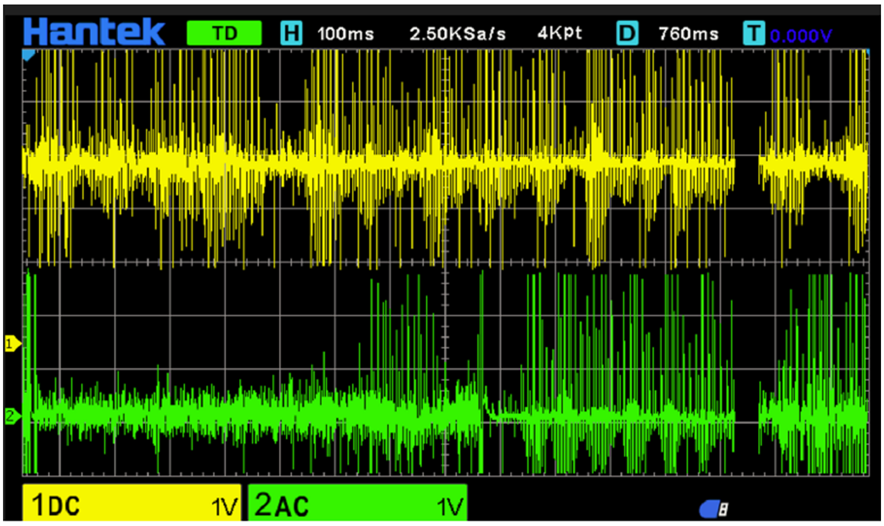
Millimeter-wave radar, a powerful technology operating within the 30 - 300 GHz frequency range, introduces remarkable capabilities in detecting and analyzing objects. With 1 to 10 mm wavelengths, this radar is positioned between centimeter and light waves, inheriting unique advantages from microwave and photoelectric navigation approaches. Some of the key characteristics and advantages include Range Detection and Doppler motion. Millimeter-wave radar can be categorized into Long-Range Radar (LRR) and Short-Range Radar (SRR). Due to the relatively low atmospheric attenuation of millimeter waves, LRR systems can detect objects over distances exceeding 1000 meters. This remarkable range positions millimeter-wave radar as a critical component in two operational modalities: local area scanning of smaller objects, Doppler motion, and range detection. The radars are remarkable for their compact dimensions and lightweight design. This efficacy allows the Integration of millimeter-wave or microwave radar with camera systems. It is prevalent in modern automotive anti-collision technologies, accounting for around 70% of current systems, and Speed Guns used for traffic speed enforcement and sports events. This statistic underscores the radar's integral role in various automated and autonomous driving features. One of the most significant advantages of millimeter-wave radar is its ability to operate effectively in diverse weather conditions. Unlike infrared or laser sensors, millimeter-wave systems excel in fog, smoke, and dust penetration, making them reliable for year-round applications. The microwave receivers with integrated horns and Waveguides are sensitive enough to detect S and X-Band marine radar transmissions from distances as far as 6 miles (See **Figure 6**). MW radar setup is shown in **Figure 7**, **Figure 8**, and **Figure 9**.

Portable Millimeter-Wave radars were employed at the Robert Moses State Park Shorefront, with a clear Southeast Line of Sight (LOS) over the Horizon facing the Atlantic Ocean. The three PODs shown in **Figure 7**, Huey, Dewey, and Louie, are hyperspectral cameras with highly sensitive environmental monitors. The name of the PODs originated from a 1970s Science Fiction drama called Silent Running, where three agricultural robots were used to monitor the environment.

The three PODs have a host of unique functions: they provide quad hyperspectral camera views and recording, binary UV and IR detectors, and millimeter-wave (MW) radar. The MW radar heads have the following specifications:

24.125 GHz, +3 dBm Transmitting Power, K-Band Dual Channel, Ranging Sensor Module;

35 GHz, +10 dBm Transmitting Power, 19 dB Receiver Gain, Ka-Band Dual Channel, Long Range Ranging Sensor Module.

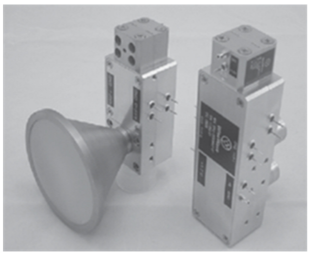


Interference pattern introduced by S-Band radar emissions from a cargo ship 6 miles off shore.

Figure 6. Time domain representation of Interference pattern produced by X-band radar from a ship on the horizon 6 miles away. Both MW range heads are displayed on a 100 ZMHz oscilloscope.

Figure 7. Phase II POD sensors with radar range heads. the PODs from left to right are named, Hewey, Dewey, and Louie.

Integral to the PODs are integrated Sensor Series Ranging Units (SSRU). These Long-Range Doppler sensors are used for distance detection of moving targets, equating Doppler shifts to precise object velocity. Two generated frequencies are used for this purpose and by frequency comparison of the two components, range and velocity can be realized (**Figure 8**).



SRU Series

The transmit/receiver with the Horn Antenna and the lens were corrected.

SSRU series ranging sensor heads are designed for long range distance detection where sensitivity is essential. The SRU series ranging sensors are used for distance detection of moving targets (where Doppler shift is presented). The technology key is to utilize a single side band up-converter (modulator) to generate a second frequency in addition to its master frequency. By comparing the returned signals from the target caused by these two frequencies, the target's ranging (Evarant Staff, 2024) [9]

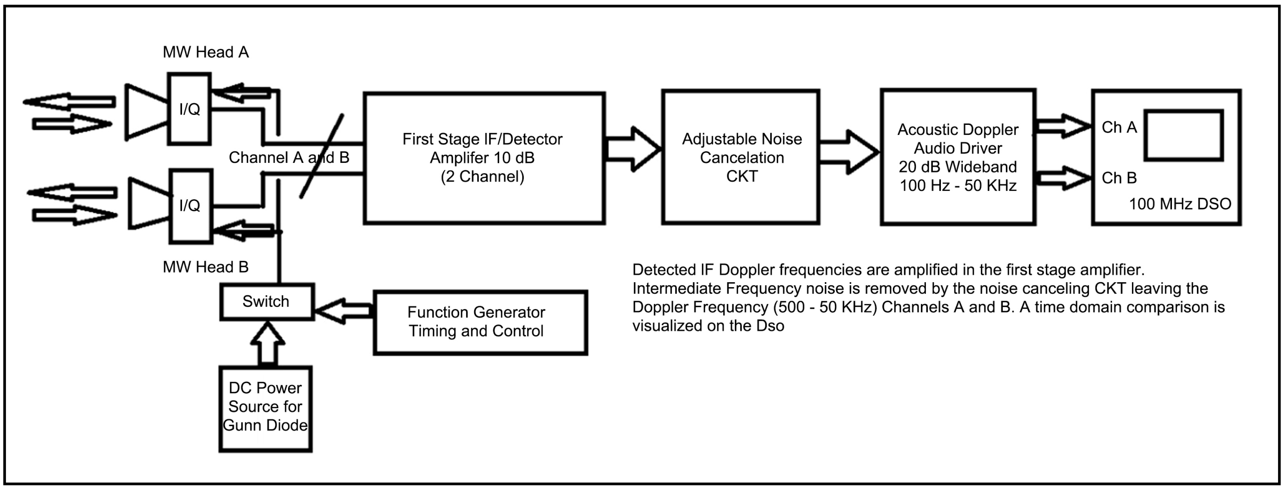
Figure 8. The transmitter and receiver doppler/range head with a lens corrected horn antenna.

Two Doppler/Range Heads extend the detection angle by cross-coupling of the return signal. They transmit an 8 mm signal wavelength with an approximate range of two miles. Figure 9 shows the two Doppler Heads at 15 degrees of center.

Figure 9. Dual doppler heads, phase pulse shifted 180 degrees, each with a 15-degree azimuth offset.

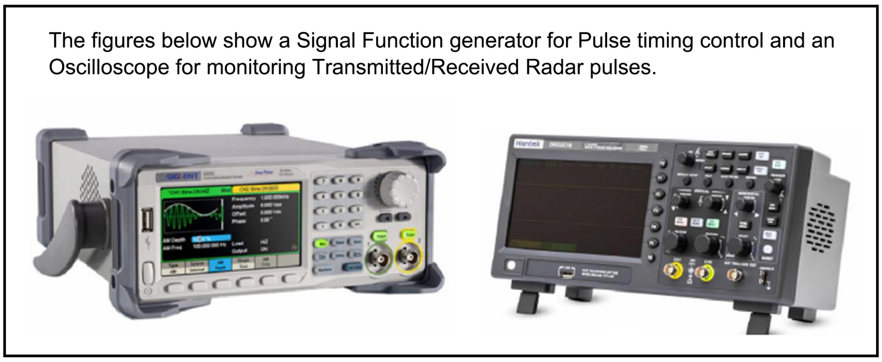
3.3. MW Doppler Range/Velocity Configuration

The high-level block diagram in Figure 10 provides front-end signal control and signal flow. Channels A and B are alternately switched on and off by a Phase-shifted Gunn diode source bias. By modulating the On-time of Heads A and B 180 degrees out of phase, we eliminate the possibility of signal crosstalk interference. Timing and control are achieved through signaling via a Function Generator (Figure 11). The intermediate frequency (IF) from the dual heads is synchronously demodulated to recover the I and Q components, which are amplified by 20 dB. A timing relationship exists between independent echoes' signal phase and amplitude. Anomalous Propagation delays can be analyzed on the DSO in either coordinate or polar form (Evarant Staff, 2024) [9].



Detected IF Doppler frequencies are amplified in the first stage amplifier. Intermediate Frequency noise is removed by the noise canceling CKT leaving the Doppler Frequency (500 - 50 KHz) Channels A and B. A time domain comparison is visualized on the Dso

Figure 10. Block diagram of MW head control and time domain visual display.



The figures below show a Signal Function generator for Pulse timing control and an Oscilloscope for monitoring Transmitted/Received Radar pulses.

Figure 11. Function generator left and DSO right.

4. Radar Anomaly Events

4.1. Case Histories of Unexpected Field Echoes

On September 19, 2023, Nightcrawler researchers documented an unexplained field event utilizing millimeter-wave radar. While monitoring a small fishing boat moving slowly through the radar's field of view, the researchers recorded an unusual radar echo, classified as an anomalous propagation of the transmitted radio wave.

4.1.1. MW Doppler Radar

The speed of the boat was calculated using a Doppler frequency shift captured by the radar, along with its range data. During the anomalous propagation of radar echo returns, an unidentified object appeared in the sky, situated in the direct line of sight of the boat. This event lasted approximately two minutes and was characterized by a loss of some radar echoes and the presence of unusually delayed return signals.

The fishing boat's speed was recorded as 5.68 mph, at a range of 1600 meters, slightly longer than 1 mile as initially determined by the MW radar. Oddly enough, as an unknown target crossed the LOS of the fishing boat, the boat's speed and range could no longer be accurately measured. This lasted approximately 2 minutes, or until the unknown object was almost 23 degrees East of the boat. An anomalous sphere of red and blue light (**Figure 12**). The object that appeared over the horizon and off the RMSP Shore had a Line of Sight (LOS) of 5 degrees. The radar track between the two MW Heads lost sync with at least five echo pulses, demonstrating a return pulse delay and missing pulse returns (Yuzhe Zhou, 2024) [10].

Figure 12. A fishing boat 1600 meters on the ocean horizon was shadowed by a luminous sphere of red and blue light. MW radar experienced a loss of target echoes during the time the object crossed the fishing boat LOS.

Figure 13 displays the timing relationship between Channels A and B on a DSO. MW Heads A and B are alternately switched on and off by 80 milliseconds to allow enough recovery time between the transmitted signal and return echo. The lower trace, Ch B, starts 80 mSec. before the upper trace, Ch A. After a brief Blanking time, four echoes were recorded on trace B. After four echoes, there is dead time, which indicates missing reflections; this can be determined by using Channel A as a reference (Hantek Staff, 2024) [11]. A frequency comparison between Channels A and B is represented in **Figure 14**.

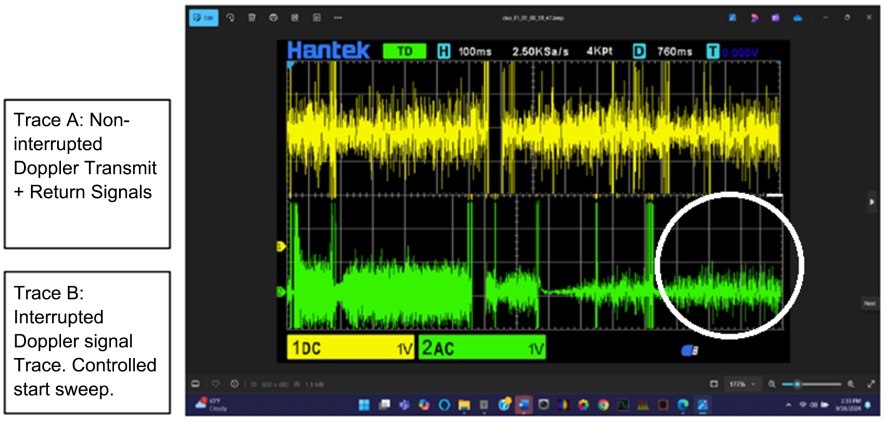
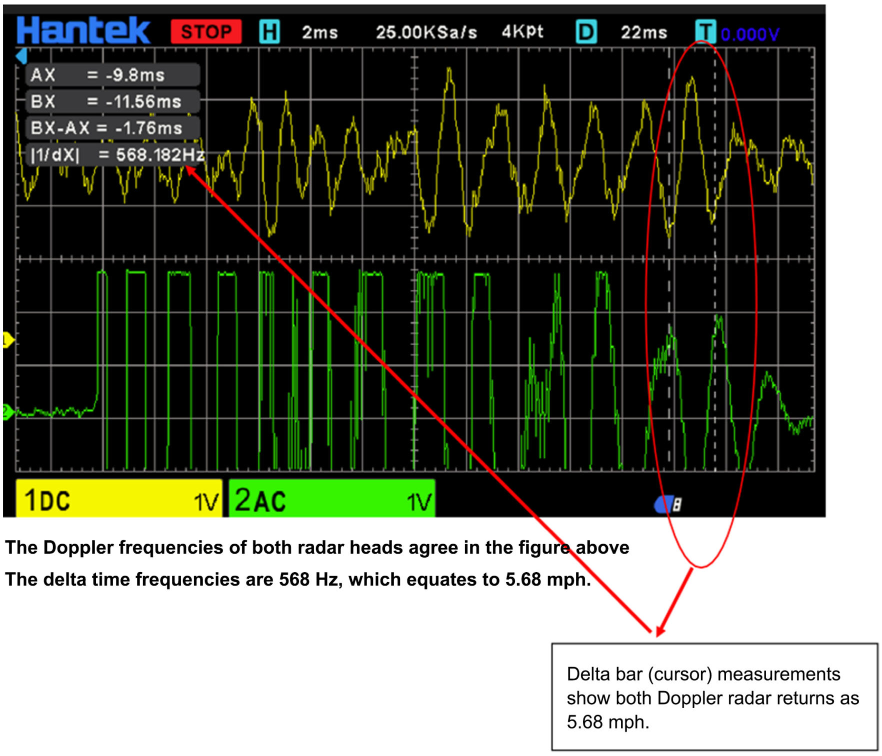


Figure 13. The image above shows the DSO Timing relationship between MW Heads A and B. Pulse return signals are switched on and off, 80 mSec apart.



The Doppler frequencies of both radar heads agree in the figure above
The delta time frequencies are 568 Hz, which equates to 5.68 mph.

Delta bar (cursor) measurements show both Doppler radar returns as 5.68 mph.

Figure 14. Magnified view of a single return pulse. When Ch B is compared to Ch A, the pulse period is the same, indicating the Doppler frequency is the same. Frequency equates to the object's velocity by taking the reciprocal of the Cycle time of 1.76 mSec. The frequency is the reciprocal of the timing period. Frequency = 1/cycle period; Frequency = 1/0.00176 = 568 Hz.

4.1.2. Doppler Frequency Shift Computations

The Doppler frequency is directly related to object velocity. This relationship is calculated as shown in Figure 15. The fishing boat speed was recorded as 5.68 mph, which is typically stated as 4.9 knots for marine vessels. One knot is equivalent to 1151 mph.

DOPPLER FREOUENCY SHIFT

The *doppler frequency* shift of an echo signal reflected from a moving target is

$f_d = (2v \quad \cos\theta)/\lambda$

Frequency Shift

$f_d = (2 \times 2.54 (\cos 5))/0.0089$

$f_d = 568$ *mph*

Radar Wavelength

y = c/f = 300,000,000/35 GHz = 0.0086 meters (8.6 mmW)

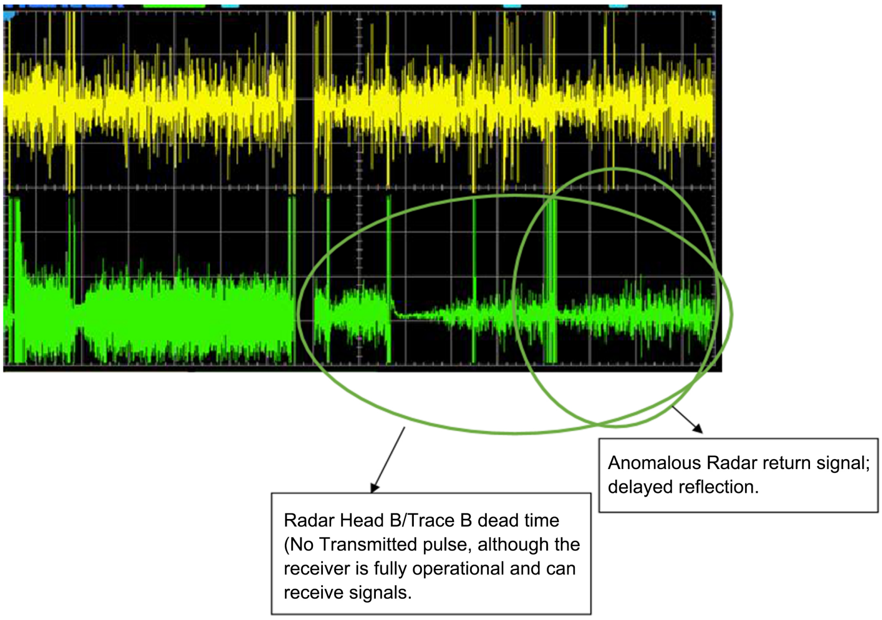
where

f_d is the frequency shift in hertz,
v is the velocity of the target in meters/second,
λ is the wavelength in meters.
θ is the angle defined by the direction of target travel and the radar line of sight to the target.

Velocity in mph to m/s = mph/2.237
5.68 mph/2.237 = 2.54 m/s

Figure 15. Doppler frequency equation is used to determine the frequency, which, when used with a coefficient, equates to object velocity.

Figure 16 below is a time-domain analysis of the event. Trace B at the bottom of the graph shows delayed and missing echoes and a suppressed Intermediate Frequency (IF) noise floor. The burst pulse before the dead time, **Figure 9**, gives the velocity of the fishing vessel. No other additional echoes were recorded until 25 seconds later, once the anomalous object transversed almost 15 degrees to the east of the fishing vessel.



Anomalous Radar return signal; delayed reflection.

Radar Head B/Trace B dead time (No Transmitted pulse, although the receiver is fully operational and can receive signals.

Figure 16. DSO time domain display of the dual Doppler channels. The lower trace B, indicates Delayed and missing pulse activity with low noise floor and dead time.

4.1.3. 3 cm, X-Band Radar Event

The images below, in **Figure 17**, represent three events using a Vertical Scanning radar system. The PPI display was taken from a Furuno 1715 Vertical Scanning radar. The Radome antenna is mounted on a Y axis to give a 180-degree sweep of the sky. This gives us the advantage of getting a cross-sectional scan of an object at a Zenith above the nightcrawler, with altitudes greater than 40,000 feet. There are 6 PPIs representing three different events. Unidentified targets were within a 5.7-degree sweep of the 3 cm beam. The objects were not visible in the 400 to 700 nm visible wavelength. Night vision cameras were required to visualize these objects, which were only radar visible in one case, which can be seen in the third image in the upper right. The objects in the other two cases did not produce a radar profile (Reddit Staff, 2010) [12]. The object in the third image, upper right, showed a range of approximately 3.3 miles. The azimuth was 15 degrees from the horizon.

The third image in the top row shows an intermittent anomalous echo in quadrant 1 of the PPI display. This represents the blue luminous orb (**Figure 18**). A boat on the ocean horizon is not visible due to its low profile on the horizon. During this anomaly, the Scanner experienced multiple echo returns in multiple radius vectors scattered throughout a 360-degree scan.

Figure 17. The effects of UFE Propagation interference patterns. Pre and Post-effects of the Transmitted and Received signal containing Burst echoes. The magnification effect, possibly due to Gravitational Lensing, gives the appearance of a magnified signal with multiple pulse echoes and decreased pulse range. The images shown are multiple events recorded from a single Y-scanning radar system.

Figure 18. Case history event 2. A 3 cm radar was used during this AP UFE event. A blue orb of luminous energy can be seen over the ocean horizon.

These unusual echo anomalies are AP distortions, which are not likely due to typical refractions from other known targets for a few reasons. The rotational Arc of the Scanner is limited to 165 degrees of sky, limiting smaller, low-profile targets, such as the boat, from the Scanner beam angle at a 3.4-mile range. The radar blind surface arc range at the mid-horizon is 220 feet. This is based on an active radial return of no less than 7.5 degrees. greater than from due to its possibly due to Gravitational lensing emanating from the ocean surface. No measurable atmospheric temperature inversion layers were viewed by FLIR radiometric data. Environmental factors such as humidity, dew point, temperature, and wind conditions did not support conditions conducive to temperature inversions, air mixing conditions, a 10,000-foot cloud base, upper-level cloudy skies, daytime heating, and gusty winds. indicated dry conditions and low temperatures, which do not support Atmospheric Temperature Inversions.

The appearance and alignment of the unknown and anomalous object with the Vertical Radar Scanner, displaying visual LOS blue and red shifting within the LOS of the radar beam, correlates with other recorded AP interference anomalies. The observed interference period, which we have recorded as having a statistical significance, supports gravitational lensing. It is typically observed as a visual effect that occurs in deep space when a massive celestial body bends light from distant stars due to massive celestial objects distorting the Space-Time fabric around them. We theorize that the same gravitational effects can occur as a relational consequence of UAP, possibly from a propulsion system distorting or altering gravity around its center of mass—Gravitational Lensing within the LOS of electromagnetic wave propagation at any frequency should impose the same or similar effects as that which is observed in deep space.

The lensing effect can be pre- or post-echo-propagation. All electromagnetic wavelengths stretching from Ionizing radiation, UV, visible light, IR, and radio waves are subjected to the same rules as light waves. Transmitted and received radar signals are influenced similarly by strong gravitational forces that influence wave propagation, creating an interference pattern on the Plan Position Indicator (PPI) pre- and post-propagation. The received signals include early burst echoes and magnification effects upon both transmitted and received signals, with shorter wavelengths/decreased perceived timing of the echoes caused by the gravitational lens. This creates a kind of illusion akin to a phantasmagoria or mirage due to amplification. Notably, the receiver does not experience any echo energy loss due to Gravitational Lensing. Echoes that arrive earlier effectively bridge the distance to the receiver. The lensing effect on light photons parallels that of radio waves at lower frequencies, with theoretical predictions suggesting that the effects would be more significant at greater wavelengths or lower frequencies.

Figure 19 shows correlation images of Case history event 2. The UFE from two independent radar systems of a known reference target and at least one unknown anomaly in the LOS of a maritime vessel and within the LOS of the Research RV. The monochrome display shows a Y-Scan radar PPI displaying multiple echoes. The Chroma image on the right displays a known Long-distance target dead south of the Horizontal (X-Scan) radar and an observed unidentified object at roughly Dead Heading at a 4.2-mile range. The unknown target was approximately 400 meters in elevation. The image shows a similar interference echo track and pattern pitch.

Figure 19. A correlation between two independent radar systems in two scan geometries. The image on the left is scanning on a Y-axis, 180 degrees skyward front to back. The image on the right is an X-axis, 360-degree circular scan of the horizon. The patterns are the same, with echo pitch and count. This indicates that the timing/distance relationship is the same for both independent signals—an omnidirectional effect with no directionality other than the source.

The image in Figure 20, left is a Vertical scanning Radar exhibiting what we believe to be LDE returns. The radar range was set for 8 NM, 2 NM per ring. The image on the right shows an intermittent object on the 3-mile range mark in the second quadrant of the PPI. After the second ring, at 6.4 miles, is a freighter. The radar echo crosses the LOS of the anomaly, at 3 miles, in the LOS and between the Scanner and the Reference target. The trailing signal behind the known target represents what we believe to be the same phenomenon shown in the left image.

Based on the data recorded in this study strongly supports the possibility that the physical nature of UAP manifests a form of gravitational lensing effect that extends beyond its perceived visible/nonvisible appearance, which can be subjective to the individual viewer. The science and instrumented signal analysis suggests the apparent AP to be the root cause of Unexplained Field Echoes (UFE) and Long-Delayed Echoes (LDE) observed in Figure 19 and Figure 20, which are derived from known reference targets, such as a large seagoing vessel. The interference pattern is speculative. Supportive data suggests Anomalous Propagation of the echo returns, the root cause of which may, in fact, be the gravitational lensing associated with UAP. The complex nature of these forces gives the appearance of Echo stretch and compression, affecting the timing relationship between the Scanner position and echo return in non-synchronized target areas, extending across PPI quadrants. Notice that despite the extended trace, the gain or energy level of the return is not attenuated by what would typically show signal attenuation as a change in intensity or, in this case, the color of the return signal.

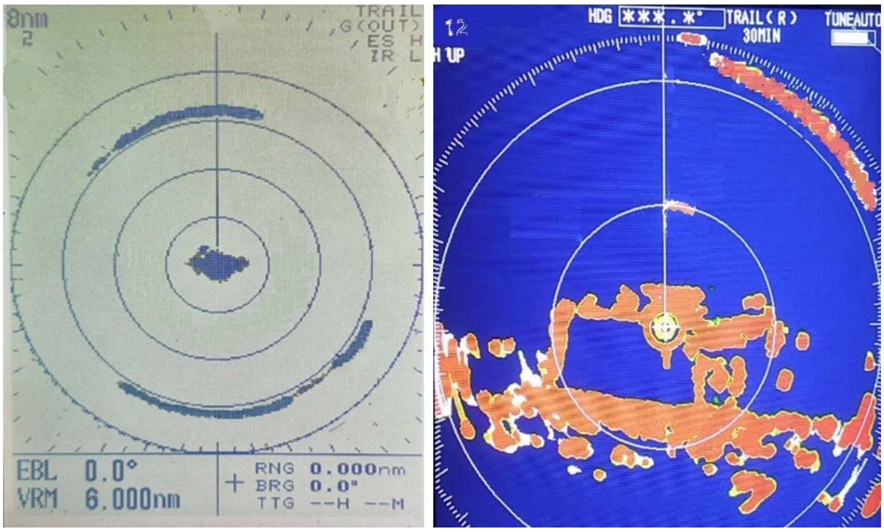


Figure 20. Correlation images from two independent radar systems. The Chromatic image on the right shows an X-Scan radar PPI with an extended range tracing over a significant length of time, exceeding return echo norms. The Y-Scan Monochrome radar system records similar return echo dynamics in the left image. Both independent radar systems demonstrate remarkably similar patterns during scan times when anomalous objects appear in the LOS of the Scanner.

Figure 21 shows the actual picture taken of the known and unknown targets. The unknown target intermittently displayed on the PPI is immediately over and slightly right of the larger reference target.

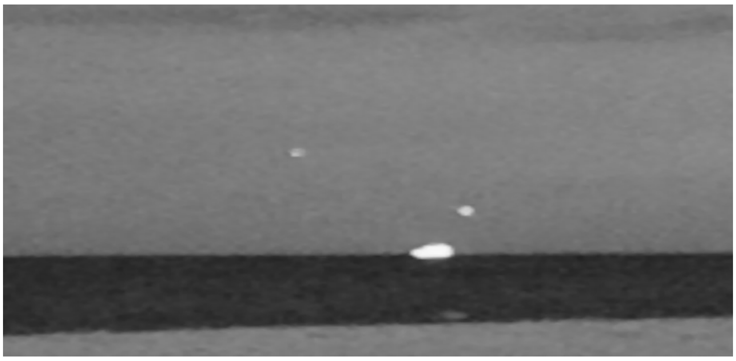
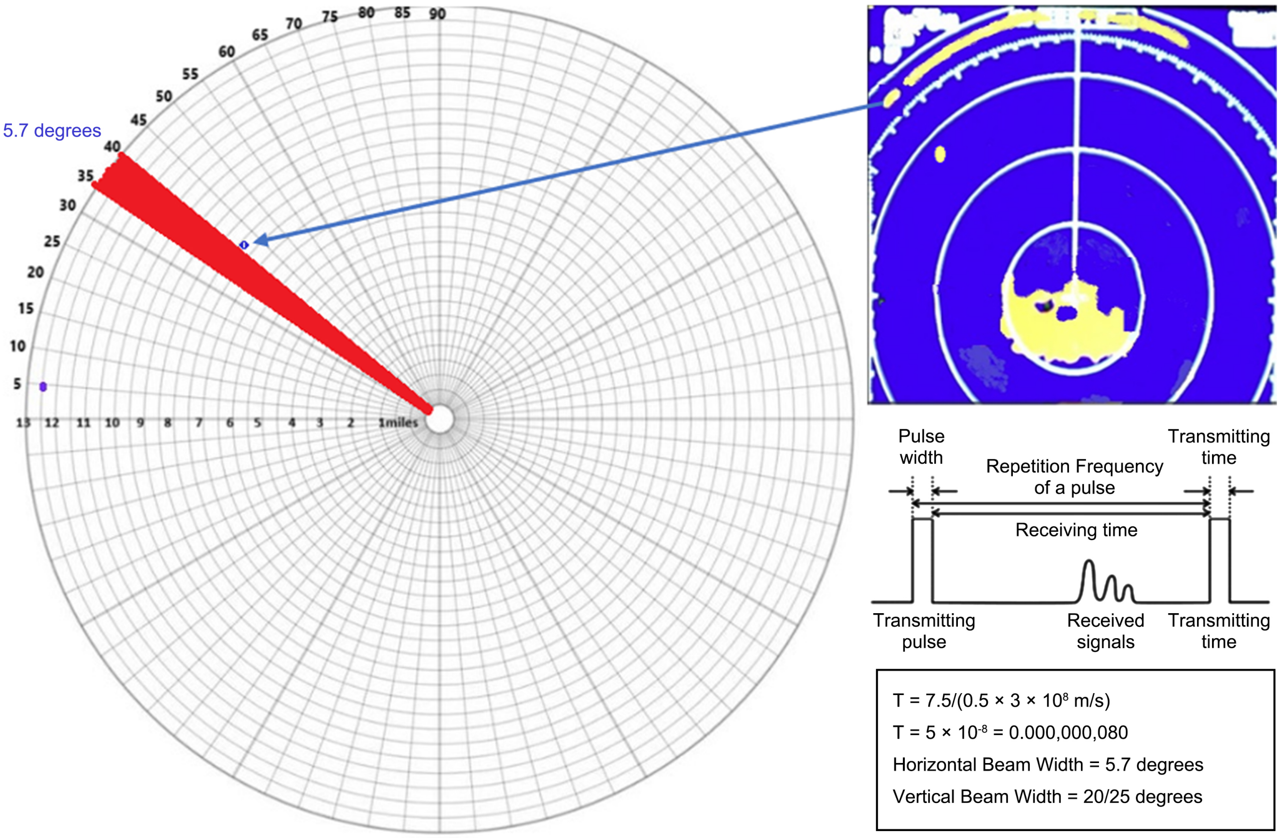


Figure 21. It shows two objects in the Nightcrawler's LOS; one of the objects produces an intermittent radar echo and a reference primary echo.

The data correlation between two independent radar systems in **Figure 18** and **Figure 19** is a crucial finding. The two radar anomalies presented on PPI displays with similar patterns provide valuable insights—the trailing echoes of the ship in **Figure 20** chases Scanner rotation by a 3 to 5-millisecond delay. An examination of the Synchronously Detected I/Q data signals does not show a predictable pattern that we would expect based on known radio wave velocity and recorded distance. Signal echo timing does not synchronize with the Scanner's 5.2-degree rotational arc, sporadically missing return echoes. These echoes show up delayed and retrieved during multiple rotations of the Scanner. We do not rule out propagated echoes redirected by gravitational lensing and refracted from the sea surface. The delayed multiple echoes over such a considerable distance, displayed over a significant period of time, produce a hard return trail and raise the possibility that an LDE has occurred. The potential implications of an LDE occurrence are significant, underlining the urgency of our findings. A correlation from two independent sources reduces the possibility of an internal hardware failure.

The reference diagram in **Figure 22** shows the angular relationships between the ship and unknown objects. The ship's return echo would be wide enough to cross the object's path and alter its propagation. The diagram demonstrates RF wave front dynamics. The Scanner, a crucial component in our data collection process, makes one complete 360-degree rotation of the environment within 2.5 seconds.



T = 7.5/(0.5 × 3 × 10^8 m/s)

T = 5 × 10^{-8} = 0.000,000,080

Horizontal Beam Width = 5.7 degrees

Vertical Beam Width = 20/25 degrees

Pulse Width = 0.08 uS
Pulse Repetition Time = 1/840 Hz = 1.19 mS
Rotational Speed = 60 Sec/24 rpm = 2.5 Seconds
Time to Scan 5.7 degrees = 2.5 Sec/(360 degrees/5.7) = 39 mSec

D = 1/2 × CT
D: Distance between the Radar and the targeted object
c : Speed of light 3 × 10^8 m/s
T : Time elapsed between first emission and reception of an echo

Figure 22. Scanner beam dynamics.

Common radar interference patterns include several types. These include "ghosting" (false targets due to reflections from objects like buildings), "clutter" (stationary false targets from non-moving objects like trees), "streak noise" (linear patterns from other radar signals), "pulse interference" (patterns appearing in specific range gates due to pulsed interference sources), and "chaff" (dense clouds of false returns created by deployed metallic strips to confuse radar systems). These can appear as a large, irregular area of interference depending on the type of radar and the source of the interference. Weak interference signals from sources outside the radar's main beam can appear as sidelobe contamination on the radar display. These echoes are typically not hard return echoes displayed in dark contrasts or defined vivid colors, such as red. The energy of the received signal is significantly attenuated.

4.2. Scanner (Antenna) Beam Dynamics

During a 2.5-second full rotation, the beam can pick up a ship at 7.5 miles for only 6 degrees of rotation, or 39 mSec. This makes full quadrant echoes impossible without radio wave distortions changing their path and trajectory.

4.3. The Role of Unknown Objects: Enigmatic Objects

As we unearthed the complexities of radar anomalies, the palpable evidence grows towards enigmatic objects secluded within the radar's peripheral awareness zone. Extant atmospheric elements can rearrange radar interactions, but the driving force remains the prospect of minute unidentified entities nesting along our scanning borders. Instances of unidentified echo strands acting as shadow proxies suggest a veiled dimension of engaging aerial phenomena exacerbating radar ambiguity. As we cross-reference between radar amplifications and historical UAP encounters recognized within maritime reporting, a comprehensive convergence of knowledge emerges, challenging our traditional ideals of transmission mechanics and aerial observance.

A principal factor binding the mysteries of anomalous propagation involves the existence of enigmatic entities affecting radar discernibility. While certain atmospheric phenomena tied to mixed mediums between radar systems and monitored vessels could significantly influence the signal integrity, the chance remains substantial concerning the impact of smaller, unknown objects infiltrating the radar's periphery.

These elusive presences may uniquely characterize their interaction with radar signals, yielding unusually scattered reflections or disruption, thus conditioning abnormal returns contradicting expected normative behavior. Intriguingly, physical analogies can draw fiber to phenomena such as gravitational lensing, which more commonly dominates discussions in cosmic perspectives where mass influences light trajectories. Here, similar mechanistic interplay may lurk in radar operations, granting momentum to hypotheses regarding objects inducing uncanny radar signature returns.

4.4. Potential Gravitational Lensing Effects

Gravitational lensing of radio waves occurs with no loss in energy, meaning the radio waves are simply bent and redirected by the gravitational field of a massive object like a galaxy cluster, Blackhole and possibly the byproduct of Propulsion, but their overall energy remains the same as they travel through space; Einstein's theory of general relativity predicts this phenomenon and applies to all forms of electromagnetic radiation, including radio waves, visible light, and X-rays, as the bending of light is solely dependent on the gravitational field and not the wavelength of the radiation itself (Giovanni, Tambalo; Zumalacárregui, Miguel; Dai, Liang, 2023) [13].

The gravitational field bends the path of the radio waves, deflecting and magnifying them. This can create multiple images of a distant radio source or form a "gravitational lens" that magnifies and brightens the image of a background source.

Gravitational lensing is a fascinating phenomenon that affects visible light and radio waves as they travel through the universe. Much like how strong gravitational fields, such as those from massive galaxies or galaxy clusters, can bend light, they can do the same for radio waves. Here are some key effects and implications of gravitational lensing on radio waves.

4.5. Key Effects of Gravitational Lensing

1) Bending of Wave Paths: As radio waves pass near a massive object, their paths are bent due to the curvature of spacetime predicted by Einstein's general relativity. We suspect UAP is capable of the same. This ensures that the radio waves experience a lensing effect without losing energy. Radio waves would appear to be in a different position from where they should be, and radar signals would place an object influenced by this effect in a different position.

2) Multiple Images: Just like light, radio waves can create multiple images of a distant source if they encounter a sufficiently massive lens. This can lead to several distinct signals appearing at different angles, which telescopes can detect.

4.6. Multiple Anomaly Event

The images in **Figure 23** were taken from Nightcrawler's X-Scan radar at 2 AM on February 13th, 2022. The location was at Robert Moses State Park, facing South, overlooking the Atlantic Ocean. The mobile lab was approximately 106 meters from the water's edge. Each Ring on the PPI represents 0.125 NM. The wedge-shaped displays show intermittent presentation of objects due to either the fast movement of the objects or intermittent presentation. The presence of Gravitational lensing could distort radio frequency pathways, where return echoes fall outside the rotational Arc of the Scanner. Sea conditions were calm, with buoy data showing 1 to 2 feet wave heights. Wave crests can sometimes appear on the radar if Sea Clutter is not compensated prior to operations. This was not the case here; wave heights were minimal, and sea clutter was compensated. Our team performed a routine Self-test and calibration procedure to rule out some more apparent scenarios, such as a radar or display glitch. Sea Clutter Gain adjusts vertical beam width sensitivity. Other conditions that could produce interference are sea spray and fog. Neither of these played a role on the night of observation. Our engineering team designed the radar antenna to be pitched upward as much as 30 degrees by an articulated arm to allow higher altitude scans, as much as 60 degrees of sky. Pitching the antenna also eliminates false returns from surface scans. The diminished land is immediately observed in this case as the radar looks skyward.

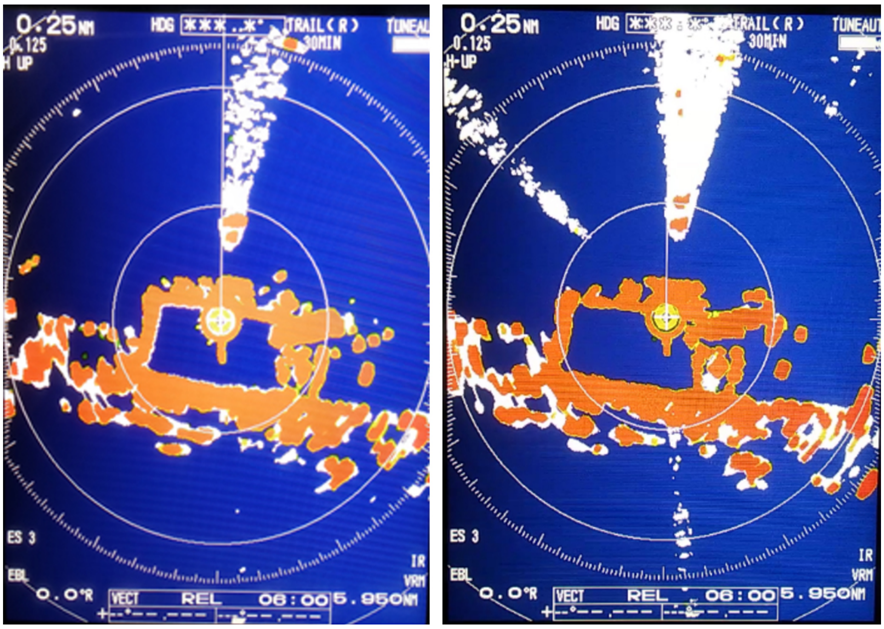


Figure 23. February 13th, 2022, incident: The Left image occurred at 2:00 AM, and the right image was at 2:15 AM. Notice the third wedge on the bottom of the image (In the rear of Nightcrawler). This could be both UFE and LDE interference.

The wedge-shaped returns remained even after Scanner pitching and reduced Sea clutter sensitivity. The white color surrounding red object echoes is produced by an Echo trail recording, which records the last position; over time, the PPI screen can take on a painted appearance as objects move about and disappear. that remains after the scan. The altitude of these returns is estimated to be between 200 and 1000 feet based on Scanner elevation and pitch. These objects were not visible to the naked eye and were only visible through Night Vision equipment, allowing the ability to see low light-infrared visibility.

The wedge produced by echo trails left behind these objects was not position-based. After repositioning the mobile lab, the pattern again established itself within the scanner's FOV. This was an interesting presentation because it seemed to demonstrate awareness of Nightcrawler and possibly a form of electromagnetic migration. This bizarre behavior recorded on radar continued until 5:30 AM. Spheroid-shaped objects were observed on the Ocean horizon, visible only through night-vision equipment, The unknown objects meandered in loose pairs and disorganized groupings. Some appeared to disappear or fade away suddenly.

The following statement is a supposition, but the radar activity resembled swarm behavior. We saw no evidence to suggest an atmospheric or weather event to account for what was observed. Secondly, a dredging project was underway to rebuild the coastline after several years of coastline erosion, especially Hurricane Sandy. At one point during the observation, four to six luminous spheroids simultaneously appeared with radar targets. They were observed hovering above the Atlantic Ocean south of the seashore.

3) Magnification of Signals: Gravitational lensing can amplify the strength of radio signals from distant sources. When radio waves pass through a gravitational field, they can be focused similarly to how a magnifying glass works with light, resulting in clearer and brighter signals from radio sources like jets emulated from active galactic nuclei. Radio wave echoes can appear to be smaller targets with well-defined echoes. Suppose the transmitted radio pulse hits a target before returning through a Gravitational lens. In that case, the target can potentially be multiplied by occurring sooner, appearing to bridge the distance between transmitted + Received echo—a Phantasmagoria or mirage to the receiver (See Figure—targets with decreasing ranges. Magnification due to properties of Lensing may have early occurring echoes, closing the distance of the return signal. This potential can give a PPI appearance of a Racon-like image.

4) Spectral Independence: One remarkable characteristic of gravitational lensing is that it is independent of the type of electromagnetic radiation, meaning it applies equally to radio waves as to visible light or X-rays. This uniformity shows the universality of gravitational effects across the electromagnetic spectrum.

5) **Implications for Radio Astronomy** Researchers use gravitational lensing as a powerful tool to study distant celestial objects. By analyzing the lensing effects on radio waves, astronomers can gather information about the characteristics of the lensing object (e.g., its mass and structure) and the source of the radio waves.

6) Redshift and blueshift Refer to the apparent change in the wavelength of light depending on whether an object is moving away from or towards the observer, respectively, while gravitational lensing is the bending of light around a massive object, or source of a concentrated gravitational force, Wormhole/UAP causing the image of a background object or local light to be distorted and magnified, acting like a lens. Redshift and blueshift are both wavelength shifts caused by the relative motion of a light source or other wave (Hopkinson, Alice, 2023):

Redshift

A shift from shorter to longer wavelengths or higher to lower wave frequencies. This occurs when a light source moves away from an observer, stretching out the light waves and shifting them toward the red end of the spectrum.

Blueshift

A shift from longer to shorter wavelengths or lower to higher wave frequencies. This occurs when a light source moves towards an observer, shortening the wavelength of the light waves.

The terms redshift and blueshift come from the colors red and blue, which are the extremes of the visible light spectrum. Redshift and blueshift can apply to any part of the electromagnetic spectrum, including radio waves, infrared, ultraviolet, X-rays, and gamma rays. The images in **Figure 21** were taken from two different sources. The left image was that of a Suffolk County Police Officer taken in the early morning hours in August of 2023 over an area in central Long Island, NY. The Nightcrawler team took the image in November of 2022 at 2:30 AM. Both images demonstrate a strong gravitational force around the unknown objects, believed to be gravitational lensing (Hopkinson, 2023) [14].

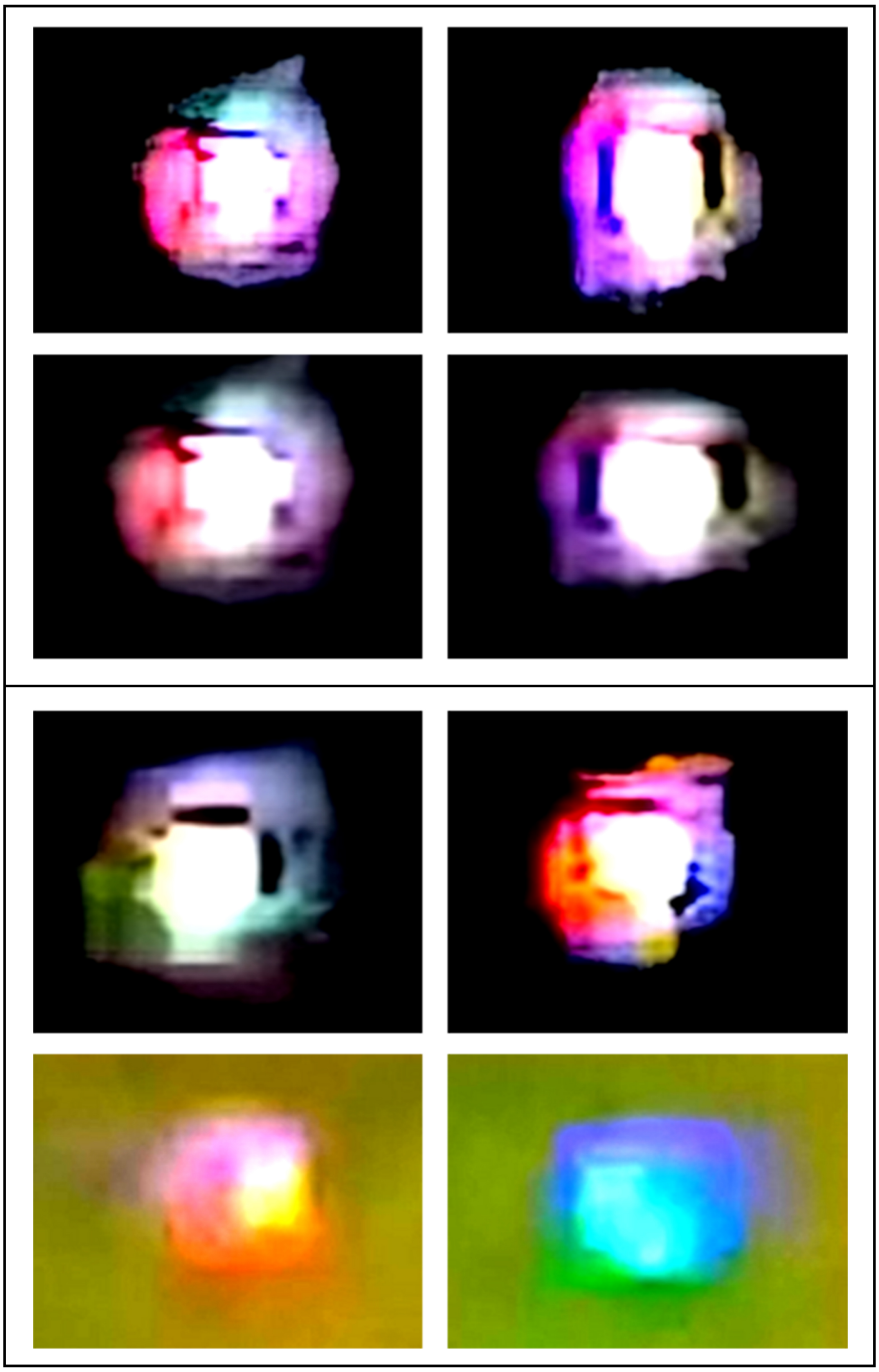


Figure 24. Doppler shifts around these unknown rotating objects are believed to result from gravitational lensing.

The images below were taken from videos of a Suffolk County Police Officer's cell phone and taken from one of Nightcrawler's observations at RMSP, merging UAPs below a cloud layer. Gerry and I believe, based on Radar, GPS, LIDAR, and Video data, that what is occurring with chromatic change around the objects, the Long Delay Echoes (LDE) coming back as echoes on three different radar systems, and LIDAR may very well be Gravitational Lensing taking place around the objects. We believe this to be a complex orchestration of three forces acting within a powerful Gravitational Source/Field or producing it. The forces are similar to those associated with the rotation of a motor Armature. These are governed by Laws associated with Electricity and Magnetism: Faraday's Law of Induction, Ampere's Circuital Law, Lenz' Law, and the Lorentz Force. All are part of Maxwell's equations, which are well understood by electrical engineers and Physicists. Astronomers observe wavelength changes of light in proximity with large body masses as these masses warp the Space-time fabric around them. We believe the same mechanism might be taking place around UAP as a possible function or by-product of a propulsion system. As with anything in the electromagnetic spectrum, light, radio waves, or cosmic rays, the same forces produce the same effect. The objects in the images are Redshift as the object rotates away from the observer and blueshift as they rotate toward the observer. The two dark areas might be intense gravitational bending within the object center, where the fields emerge at one end and collapse inward on the other.

The images in Figure 24 were taken from a Suffolk County Police Officer on patrol.

4.7. The Importance of Investigating Signal Behaviors

The phenomenon of gravitational lensing emphasizes the need for comprehensive studies of how existing signals are affected by these gravitational influences. When considering real-world applications, such as radar technology, understanding how environmental factors like gravitational fields can modify impressions from radar returns helps refine distance measurements and enhance object detection capabilities. This research also amplifies the significance of conceptualizing and interpreting navigational and communication signals, as distortions may occur due to these gravitational interactions, influencing our understanding of a vast array of phenomena—from astrophysical to anthropogenic signals on Earth.

Gravitational lensing can effectively "slow down" radio waves by causing them to travel a longer path due to the bending of spacetime around a massive object. This results in a time delay in the arrival of the radio signal at the observer; however, it's important to understand that the radio waves themselves are not actually traveling slower through space, just taking a longer route due to the gravitational distortion.

Key points to remember:

No change in local speed:

Even though the radio waves appear to be "slowed down" by gravitational lensing, their speed at any given point in space remains the same as the speed of light in a vacuum.

Path distortion:

The gravity from a massive object like a galaxy or black hole warps the spacetime around it, bending the radio waves as they travel past, making them follow a longer path to reach the observer.

Time delay:

This longer path delays the radio wave emission and reception, which we perceive as a "slowing down" effect. Gravitational lensing is an intriguing field of study for pure astronomy and practical applications in radar technology and signal processing. It highlights the intricate interplay between the cosmos and our technological landscape.

Understanding phenomena derived from subtle influences underscores the calling to conduct thorough evaluations on signal behaviors that remain already affected by this environmental interaction landscape, energizing interests surrounding tails of echo characteristics cloaked amongst navigational signals recognized nationally or globally (Center for Astrophyisics Staff, 2022) [15].

5. Discussion

With radar systems impacting expansive waters, it is crucial to clearly define and carefully analyze the numerous potential factors—both atmospheric and exotic—that highly elusive objects exert on radar signals during maritime missions. Therefore, it is essential to advocate for ongoing empirical investigation, a responsibility grounded in systematic data that highlights the intricate signatures associated with unconventional propagation patterns.

Through focused observation, thorough analysis, and proactive operational improvements, our ambitions are to implement strategic mitigations that address misleading echoes while fostering enhanced clarity within our technologies. Additionally, the efforts described contribute to probabilistic refinements in navigation protocols aligned with the growing maritime interests directed towards strengthened responses to existing anomalies.

Gravitational lensing is a fascinating astrophysical phenomenon in which the gravitational field modifies the path of light or other electromagnetic waves, including radio waves. This occurrence enables these waves to follow remarkably bent trajectories without apparent energy loss. Instead, they traverse through a warped structure of spacetime created by substantial celestial bodies such as galaxies, black holes, wormholes, and that which may pertain to UAPs.

1) Path Alteration of Waves: The path of radio waves is altered by the gravitational effect of a massive object, bending in accordance with Einstein's general relativity. This bending does not reduce the energy of the waves, demonstrating that their integrity remains uncompromised as they journey through the cosmos.

2) Multiple Images and Routes: Gravitational lensing adds hesitation to how we perceive distant radio sources. Radio waves traveling near a significant

Gravitational Field can generate multiple observable images from the original source due to their altered light-like paths. Consequently, an observer may receive several distinct signals from what is fundamentally a single source.

3) Signal Enhancement: Gravitational influences can potentially amplify radio signals. By compressing and directing the wavefronts, gravitational lensing increases the observed intensity of these signals, which aids astronomers in studying faint cosmic phenomena, such as emissions from active galactic nuclei.

4) Independence of Spectrum: A compelling characteristic of gravitational lensing is its universal applicability. The principles that govern visible light also pertain to other areas of the electromagnetic spectrum, including radio waves. This consistency reinforces the robustness of gravitational interactions across different forms of radiation.

5) Importance of Radar Technologies: The consequences of gravitational lensing go beyond cosmic observation; they are also relevant to technologies like radar systems. As these systems frequently engage with echoes and reflected waves, comprehending how gravitational fields influence signal behavior is essential. Recognizing these perturbations allows operators to refine distance measurements and improve detection capabilities, ultimately enhancing the accuracy with which we discern objects obscured by gravitational effects.

6) Time Delays and Path Lengths: An intriguing feature of gravitational lensing is the effective "slowdown" where radio signals, under gravitational influence, may travel more extended routes. This phenomenon is not related to their inherent speed of light. Thus, any delays noticed in receiving these signals indicate increased distance rather than variations in wave propagation speed (Lintott, Chris, 2024) [16].

In conclusion, the exploration of gravitational lensing enhances our understanding of the masses that draw them to one another in the universe while offering practical solutions for navigation and communication. By investigating how these gravitational effects interact with radio waves, researchers can create interdisciplinary pathways that merge astrophysics and radar technology, ultimately enriching our comprehension of both cosmic and technological communication.

To wrap up, the urgency of exploration considers the striking potential of unusual radar returns that may reflect gravitational lensing patterns triggered by the sophisticated nature of unidentified aerial phenomena (UAP). This fusion of radar knowledge necessitates emerging interpretation through interdisciplinary methods that include maritime operations and complex meteorological factors. Hence, it is essential to continually promote our discipline-focused efforts to foster investigative dialogues while encouraging collaborative initiatives toward improved maritime navigation standards, which are vital for our collective maritime future. Given the vast waters eiating with radar systems, we must delineate and systematically dissect the numerous potential atmospheric and exotic influences that exceedingly elusive objects impose on radar signals throughout maritime missions. Thus, advocating sustained empirical examination is paramount, a duty that rests on systematic outputs asserting nuanced signatures linked to unconventional propagation modalities.

Through punctuated observation, deconstructed analysis, and preemptive operational advancements, ambitions encapsulate strategic mitigations, reconciling misleading echoes and harnessing enhanced clarity within our technologies. Moreover, efforts articulated here contribute probabilistically to refined navigation protocols catering to vast, ascending maritime interests all en route towards fortified measures cognizant of existing anomalies.

Gravitational lensing is a captivating astrophysical effect where the gravitational field of a massive object alters the trajectory of light or other electromagnetic waves, such as radio waves. This phenomenon allows these waves to appear as if they are taking miraculously bent paths without experiencing any loss of energy. Instead, they travel through the structure of spacetime, which is warped around massive celestial entities like galaxies or black holes.

In summary, the study of gravitational lensing not only aids our comprehension of attracting mass in the universe but also workshops practical applications like navigation and communication. Researchers can forge interdisciplinary pathways reconciling pure astrophysics with radar technology by assessing how these gravitational influences interact with radio waves, enriching our understanding of cosmic and technological communications.

In closing, the exploratory immediacy calls into account the verity of peculiar radar returns potentially echoing gravitational lensing tropes activated by UAP elegance interweaving radar contributions to knowledge that warrants emergent interpretations drawn fast through intrac-disciplinary methodologies encapsulating maritime operations and meteorological complexities at play. Thus, continuously nurturing in stamina our discipline-focused engagements designed to imbue investigative forums while catalyzing amalgamated endeavors towards enlightened maritime navigation standards stands pivotal for collective seafaring futures.

6. Conclusions

This comprehensive investigation into Unidentified Anomalous Phenomena (UAP) and their potential influence on radar signal transmission offers a profound insight into an area that has long piqued the curiosity of scientists, researchers, and Federal authorities. The observed Long Delay Echoes (LDEs) and Unusual Field Echoes (UFEs) challenge our conventional understanding of radar propagation and signal behavior, suggesting that these anomalies may be indicative of complex interactions occurring under specific conditions when UAP activity is present. The meticulously documented radar anomalies recorded during this study highlight the intricate relationships between technological systems and enigmatic aerial entities, unlocking the possibility of unknown physical or quantum dynamics at play that could redefine established principles in electromagnetic transmission when under the influence of exotic quantum forces change the dynamics on echoes and propagation.

The study emphasizes the necessity for a paradigm shift in how we approach maritime navigation and radar monitoring technologies, affirming that new methodologies must be developed to address these UAP-related complexities. By leveraging advanced radar systems and employing innovative analytical frameworks, future research might improve operational protocols for maritime surveillance and pave the way for breakthroughs in understanding the underlying mechanisms of anomalous propagation.

Ultimately, this research serves as a pivotal step toward unraveling the mysteries posed by UAP while calling for a multidisciplinary approach to provide clarity in the context of radar technology and unexplained phenomena. Continued exploration and a willingness to question and expand our current paradigms could lead us to new frontiers in both academic understanding and practical applications, securing our place in an ever-evolving landscape of technological advancements aligned with the ultimate aim of deciphering the elements of our environment that remain shrouded in mystery.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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