ARTICLE IN PRESS

Progress in Aerospace Sciences xxx (xxxx) xxx

Contents lists available at ScienceDirect

Progress in Aerospace Sciences

journal homepage: www.elsevier.com/locate/paerosci

Estimates of radiative energy values in ground-level observations of an unidentified aerial phenomenon: New physical data

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ARTICLE INFO

Keywords:
High-energy sources
Unidentified aerial phenomena
UAP
UFO
Radiation effects
Wood calcination

ABSTRACT

An exceptional observation of an anomalous object, recorded as ‘unidentified’ by the US Air Force and in the1969 final report of the University of Colorado (“Condon”) study of UAPs, has been re-examined by a Franco-American scientific team.

The observation took place on the evening of December 30, 1966, on an isolated highway traversing a forest near Haynesville, Louisiana. Early in 1967 the main witness, a professor of atomic physics named Louie A. Galloway, reported the case to Project Blue Book of the USAF. Pro-active investigation by one of the authors (JV) brought it to the attention of Professor Edward Condon, himself a noted atomist who had worked under Project Manhattan. Dr. Condon and his team had just begun an official re-examination of UFO (UAP) phenomena under funding of the US Air Force.

The case, which centered on a well-defined luminous object at ground level, led to energy estimates from 500 to 1400 MW, in the range of a small modern nuclear power plant. Significantly, it was one of a number of cases carried as ‘Unidentified’ in Dr. Condon’s final report to the National Academy of Sciences in 1969.

Subsequent to that Academy report, significant work was continued at the site by civilian investigators who confirmed the data, augmented by night photography flights. The team returned to the area with the primary witness, located the exact place of observation and gathered new data, notably about the nature of burns evidenced on the trees, which had not been available to Dr. Condon and his assistants.

Samples of the burned and intact bark were obtained by our own team, and they were preserved until it became possible to properly analyze the material.

The burn analysis data presented here was obtained at the laboratories of the French Atomic Energy Commission in Saclay, France. We present our results with the understanding that the study will benefit from further discussion within the larger scientific community.

1. Basic facts

An unexplained observation was made on December 30, 1966 about 20:30 C S T, at a location 1200 yards west of Highway 79, 3.6 miles north of Haynesville, Louisiana, so that the sighting itself was located in Arkansas, about one mile North of the border between the two States. The witnesses were Dr. L.A. Galloway, age 31, Mrs. Galloway age 28 and two children, ages five and seven. At the time, Dr. Galloway is a nuclear physicist, a professor at Centenary College in Shreveport, Louisiana. The area is about 30 miles NW of Shreveport, and 100 miles SSW of Little Rock, AK.

Dr. Galloway sent a standard witness report to Project Blue Book at Wright-Patterson AFB, which one of us (JV) selected out as part of a small, ongoing funded analysis of the USAF files, under Dr. J. Allen Hynek and Major Hector Quintanilla. The case was flagged as important because of the excellent detail of the observations, the background of the main witness, and the clear relevance of a high-energy event. Dr. Hynek agreed that it deserved to be submitted to Dr. Edward Condon as part of the comprehensive study of UFOs then under development in Boulder, Colorado [1].

This article is part of a special issue entitled: Unidentified Aerospace Phenomena published in Progress in Aerospace Sciences.

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https://doi.org/10.1016/j.paerosci.2025.101098
Received 16 October 2024; Accepted 25 April 2025

Following our communication with him, Dr. Condon concurred and his group undertook extensive follow-up studies, including aerial surveys. Unfortunately, they were unable to locate the precise site in the forest and therefore focused only on energy estimates and on research for any possible source of intense, persistent luminous display in the area, a search that provided no identified result.

In the main body of his final report to the US National Academy of Sciences, Dr. Condon summarizes the case as follows:

> "A family had reported observing a pulsating light which changed from a red-orange glow to a white brilliance which washed out their car headlights and illuminated the woods on both sides of the highway. The driver had to shield his eyes to see the highway. About 0.6 miles farther down the highway, the driver reportedly stopped the car and, from outside the automobile, watched the light which had returned to its original glow. The light was still there when he stopped observing and left the area about five minutes later.
>
> "Although our investigating team made an aerial survey of the area and watched for reappearance of the phenomenon, and the principal witness continued to search the area after the team left, no revealing new information was discovered, and the source remained unidentified." [2].

It is particularly interesting to find that Dr. Galloway and Dr. Condon shared an expertise in nuclear physics (Dr. Condon had been at Trinity with Dr. Oppenheimer in 1945) and were collaborating closely in researching the case on a scientific basis, with none of the usual media meddling and public arguments that often complicate case investigations. The result was an official verdict of "Unidentified" after extensive research by the Condon team [3].

2. Case analysis, as summarized in the 1969 condon commission study

In addition to the brief overview quoted above, the Condon study devotes nearly *four pages* to a detailed reference that mentions the IR photos and complete weather data. Unfortunately, despite these the team was unable to locate the actual site, but it did compile extensive records about the site itself, with help from the prime witness.

In a letter dated February 28, 1967, Major Donald R. Ryan, investigating Officer for the US Air Force, wrote to Foreign Technology Division at Wright-Patterson AFB to describe his own analysis of the case [4]. He mentioned that Dr. Galloway had returned to the area in January 1967 "and through triangulating as best he could the source of the light, computed its distance from the road from 0.7 to 1.2 miles. Using this distance estimate he later computed the power of the light source to have been 400–1200 MW"

On the weekend of February 25, 1967, he returned again with Professor John Williams [5](JV's main source for the case investigation itself in an attempt to find anything that might explain the light and found nothing. Major Ryan concluded with his "most strong recommendation that the Air Force contact Dr. Galloway and cooperate in every way in attempting to find the solution to this unexplained light."

On April 5, 1967, Dr. Louie A Galloway himself wrote to Dr. Dave Saunders at the University of Colorado [6] to report that aerial photography had been completed, along with the compilation of a chronology of events and other records. He reported that on March 23rd, he had gone back on foot and found nothing out of the ordinary at the site but had difficulty reconciling ground traces with what was on the photographs: for example, a metal tank was noticed, that was confirmed by photo-interpretation at Barksdale.

A local survey conducted by Dr. Galloway disclosed a number of unexplained sightings in the area around the time of his own observation.

Setting aside a luminous (red) object seen around early September 1966 (unreported) and another crescent-shaped, dull red object hovering at treetop level seen on September 19, 1966, five miles southwest of Haynesville (also unreported), the most serious candidates for time-related objects are the following two (unreported) observations.

(a) On December 24, 1966, Mr. and Mrs. Pete Taylor observed a very bright white light 3 miles North of Haynesville between 8 p.m. and 9 p.m. No physical object associated with the light was visible, however, as the source of the light was below tree-tops.
(b) On December 26, 1966, (four days before the Galloway sighting) Mr. and Mrs. J.H. Cockerell were driving North on Highway 79 when they saw a brilliant white light for several seconds. No sound was heard.

The Cockerells, aged 50 to 60, were the operators of a general store and service station in Haynesville. The light illuminated woods and highway "in all directions around their car."

This summarizes where the case stood at the time of the publication of the official report by Professor Condon and its communication to the US Academy of Sciences.

3. Detailed site analyses posterior to the Condon Report

The Colorado study was published in 1968 without further information about the case. It is only when Professor Galloway (the main witness) returned to the site for a more extensive search with a colleague, Professor John Williams, that the actual clearing was located and exposed trees inspected, at the location shown on Fig. 1.

A more detailed map was generated by the main witness as shown on Fig. 2, with the tracing of the old (unused) railroad and the location of the first and last observations of the luminous object, showing the clearing beyond the railroad tracks.

Also noted on the Galloway map are an old (unused) oil tank to the South and the body of a dead cow to the North of the site.

The area contains trees, underbrush and old oil wells. A burned area that showed slightly higher radioactivity than background turned out to be a burned-over oil slick beside a pumping station, unrelated to the sighting.

Contacted about the old railroad track, the chief dispatcher stated that no rolling equipment was within 50 miles of the site on that night. The nearest power lines are about nine miles to the West.

4. Physical conditions at the site

The actual site of the phenomenon is a clearing about 30 feet in diameter, characterized by the fact that the bark of trees around the periphery was blackened in the direction of the center of the clearing. Examination determined this took place as a result of exposure to the light of the object (and not to a heat source).

Neither the original report, nor the Colorado study, mention the specific type of tree affected by the radiation. We do know, however, that the area is covered with Louisiana pines, for which five major varieties account for a majority of the wooded areas. Fig. 3 shows two of the five types of pine trees common to the area.

Complete weather records for December 30, 1966 were obtained at Shreveport, some 30 miles away. At about 8:30 p.m. the sky was heavily overcast, with fog and a light drizzle, ceiling about 300 feet. No lightning activity was noticed, as noted in the University of Colorado study. The reports note high humidity and temperatures ranging from just above freezing (34 degrees F) to the low 40s during that particular day.

Sometime after the ground exploration in the Spring of 1967, pilots from Barksdale AFB flew a number of missions at three altitudes over the forest. These missions were flown at night with infrared photography equipment. A local Air Force officer who was transferred to another job out of the area contacted the witness and gave him these documents since the case was regarded as closed. They consisted in approximately sixty photographs, the most relevant of which is submitted here on

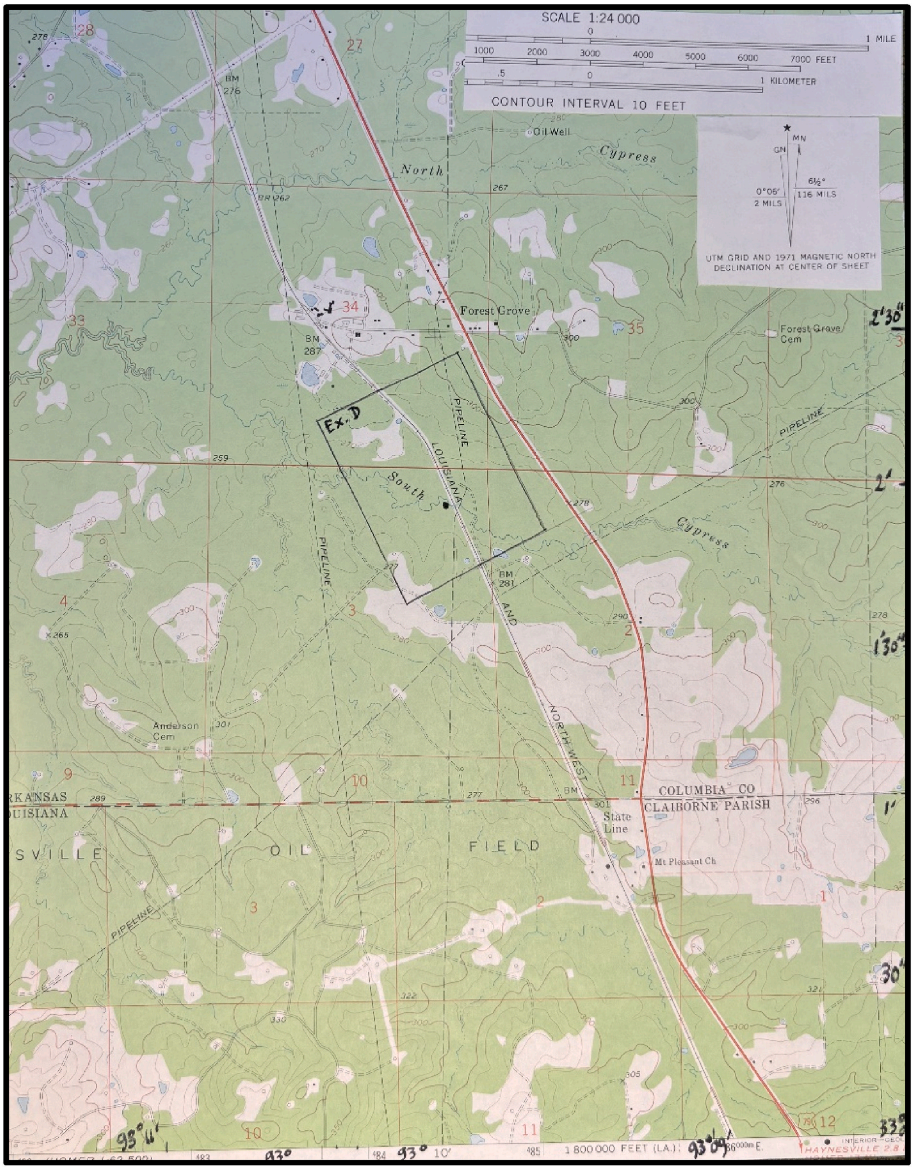

Fig. 1. Location of observation: Columbia County, AK.

Fig. 4, which also lists the weather conditions at the time of sighting. (A more complete photographic record and all weather records have been submitted to the reviewers as part of their work on this paper).

In the second half of this document, we now address the nature and intensity of energy likely to have been present at the site, and the phenomena that took place as the observers hesitated to proceed on their route, close to what was evidently a very unusual (and potentially dangerous) type of controlled illumination.

5. Initial energy calculations at the time of the condon study

High-energy events are not rare in the context of UFO/UAP reports. They are often noted to impact both human health and physical devices in consistent ways.

Among the latter effects are injuries to the central nervous system, to the skin and the eyes, as well as long-term conditions that occasionally require hospitalization and can lead to death. Physical impact (apart from known mechanical effects) is most often in the form of light energy (many cases trigger photocells in cities and villages) and detrimental impact on irradiated plants, as in this case.

Following the observation, the main witness and two other experts proposed estimates of the radiated energy, arriving at very high values, in the range of a nuclear energy generation facility. Professor John O. Williams proposed two calculations of energy, as follows. They are based respectively on the distance estimated in Condon (2400 ft, or 732 m) and with the actual distance after discovery of the site (1800 ft, or 550 m) (Fig. 4).

Calling I_u the intensity of the unknown source and I_c the intensity of the car headlights, and calling X the energy output of the unknown light, we write:

$$I_c = \frac{150\ watts}{(10\ \text{ft})^2} \quad \text{(eq. 1)}$$

With the source intensity:

$$I_u = \frac{X}{d^2} \quad \text{(eq. 2)}$$

where d is the distance of the source.

The first equation expresses the visible intensity of the car headlight at a distance of 10 feet from the driver. At that distance, the headlights were completely washed out by the unknown source, thus providing a

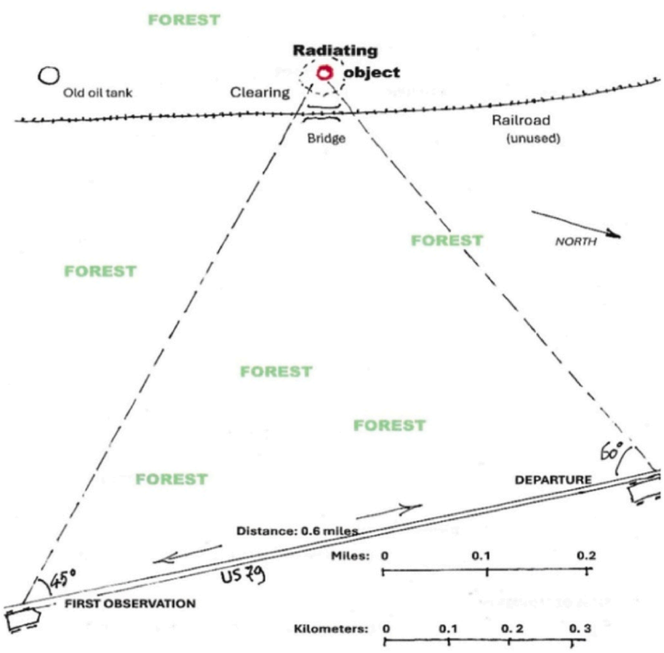

Fig. 2. Physical situation at the moment of sighting, December 30, 1966.

lower limit for I_u.

Next, we assume that we can detect a 'just noticeable difference' (JND) between I_u and $(I_u + I_c)$.

In this case, this would give, according to Wever, *JND curves* [6],:

$$I_u = 100\,Ic \quad \text{(eq. 3)}$$

We can then write:

$$\frac{X}{d^2} = 100\,\frac{150}{10^2} \quad \text{(eq. 4)}$$

or again:

$$X = 150\,d^2 \quad \text{(eq.5)}$$

To summarize, the site yields a value of 900 Megawatts at 732 m, and a value of 500 MW at 550 m.

It is noteworthy that Major Ryan, who did not know the exact location, had suggested an estimated power of 400–1200 MW, consistent with these later calculations.

These considerations were made without the benefit of knowing the precise position of the actual site and without access to materials exposed to the source of the observed radiation.

While the calculations are clearly stunning in terms of the calculated intensity, they must be redone based on the new data, including the known distance between the car and the source.

6. Recovery and inspection of bark samples from an affected tree

Following publication of the Condon report in 1968, the main witness went back to the site with colleagues for a more systematic search and discovered the actual site of the emission. They were then able to detach fragments of bark that showed exposure to the radiation.

The next step in the analysis was a return to the study of the burns affecting the bark of the tree (right box on Fig. 5), as compared with the wood of an undisturbed area shielded from the radiation source (upper left on the photograph).

The first attempt to exploit the bark samples in terms of energy exposure took place on October 12, 1978 when they were sent to a large US atomic facility for analysis. The samples were returned without any disclosure of findings and were recovered (by JV) on August 27, 1979. No further analysis was done after that date.

The samples are shown on Fig. 5 above, as they stood when our team submitted them to a series of tests in France.

6.1. Sample collection

At the edge of the clearing where the event occurred, Dr. Galloway and a colleague found that the exposed trees were still alive but their trunks had been blackened.

Only the exposed face appeared to have been altered by the exposure to the object while the other sides of these trees remained un-blackened. The two bark samples we have in our custody were recovered from the same tree: Sample A from the exposed, blackened face, and sample B from the unaltered side.

6.2. Gamma-ray spectroscopy

The BEGe-6530 gamma spectrometry detector from Canberra features several key specifications ideal for precise gamma-ray measurements. This planar detector has an active area of 6500 mm^2 and a diameter of 91.5 mm, with a thickness of 31.5 mm. The detector window is 0.6 mm thick, positioned 5 mm from the outside, and is made of

Fig. 3. Common types of trees in the area: Left: Longleaf pines, Right: Slash-pine (pinus Elliotti-Engelm).

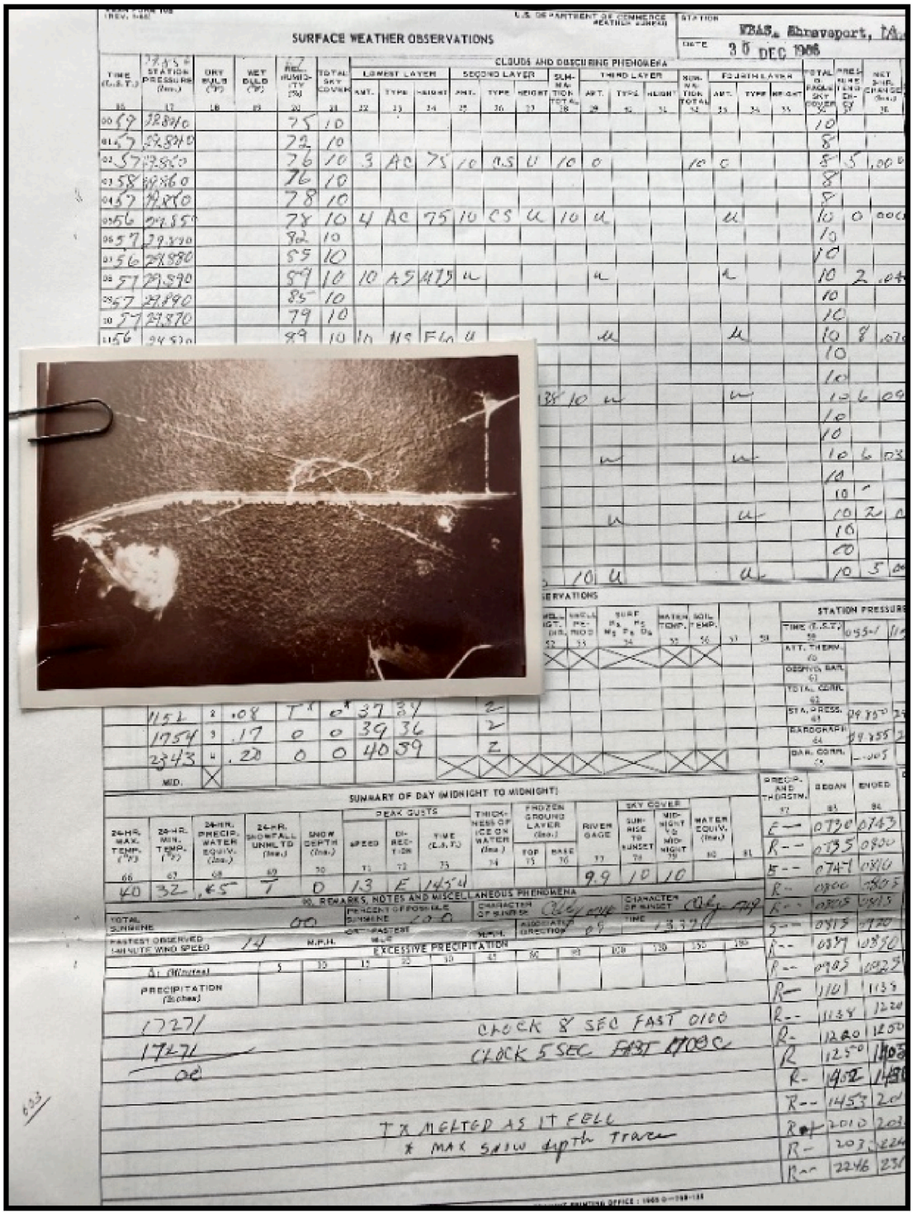

Fig. 4. Local site and weather data (and night infrared aerial photograph).

If d = 2400 (first location) this gives X = 900 MW.

If d = 1800 (second location) we find X = 500 MW.

carbon epoxy. It exhibits a relative efficiency of 60 % at 1332.5 keV for ^{60}Co.

The Full Width Half Maximum (FWHM) resolution is 0.478 keV at 5.9 keV, 0.695 keV at 122 keV, and 1.785 keV at 1332.5 keV, indicating high-resolution performance. Additionally, the peak shape (FWTM/FWHM) for ^{60}Co is 1.88, and the cryostat is designed as a vertical dipstick.

The detector surrounded by lead shielding consists of 100 mm graded lead, liners of 1 mm tin and 1.6 mm copper in order to minimize the contribution of the lead X-rays in the spectra [ref.xx]. These characteristics ensure high efficiency and resolution, making the BEGe-6530 suitable for detailed gamma-ray spectrometry analyze.

Gamma-ray spectroscopies were conducted on both samples.

Each of them was measured for 480.000 s. The obtained spectra were treated using Genie 2000 software provided by Camberra industry.

The absolute Full Energy Peak Efficiency (FEPE) of a detector is defined by the following expression:

$$\varepsilon_{exp} = \frac{N}{A.I_{\gamma}.t_c} \quad \text{(eq. 6)}$$

where A is the activity of the source for each gamma energy in becquerels (Bq), N is the net peak area at the energy of interest, corrected for background counts, I_γ is the gamma-ray emission probability, and t_c

Fig. 5. Recovered wood samples (unexposed and exposed) from affected tree.

is the counting time in seconds.

The uncertainty in the experimental efficiency is determined using the uncertainty propagation law:

$$\delta\varepsilon_{exp} = \varepsilon_{exp}\sqrt{\left(\frac{\delta N^2}{N}\right) + \left(\frac{\delta A^2}{A}\right) + \left(\frac{\delta {I_\gamma}^2}{I_\gamma}\right) + \left(\frac{\delta {t_c}^2}{t_c}\right)} \quad \text{(eq.7)}$$

The detector used for these experiments is calibrated to determine the activity of a sample contained in a cylindrical geometry such as an SG500. To avoid damaging the samples, it was decided to place the barks directly on the detector one by one.

6.3. Results and discussions

The recovered samples are barks from pine tree. All the trees bordering the clearing had their trunk blackened. We therefore consider a (quasi)isotropic source of radiation located at a distance R = 4.5 m (≈15 ft) of a bark sample.

Both samples were analyzed using the same detector. Several radionuclides, such as ^{214}Pb (Lead) and ^{214}Bismuth were identified in both samples.

For the first one, the energy rays at 242 KeV, 258 KeV, 295 KeV and 351 KeV are measured.

For the second one, the energy rays at 609 KeV, 934 KeV and 1120 KeV are measured (Figs. 6 and 7). These radioelements are part of the natural radioactivity naturally present in vegetation [7–9], unlike in sample B where at 661 KeV, there is no significant peak emerging from the background noise.

On sample A, ^{137}Cesium is clearly identified (Fig. 6) at the energy of 661 KeV. Determining the activity of the ^{137}Cs is not feasible here due to

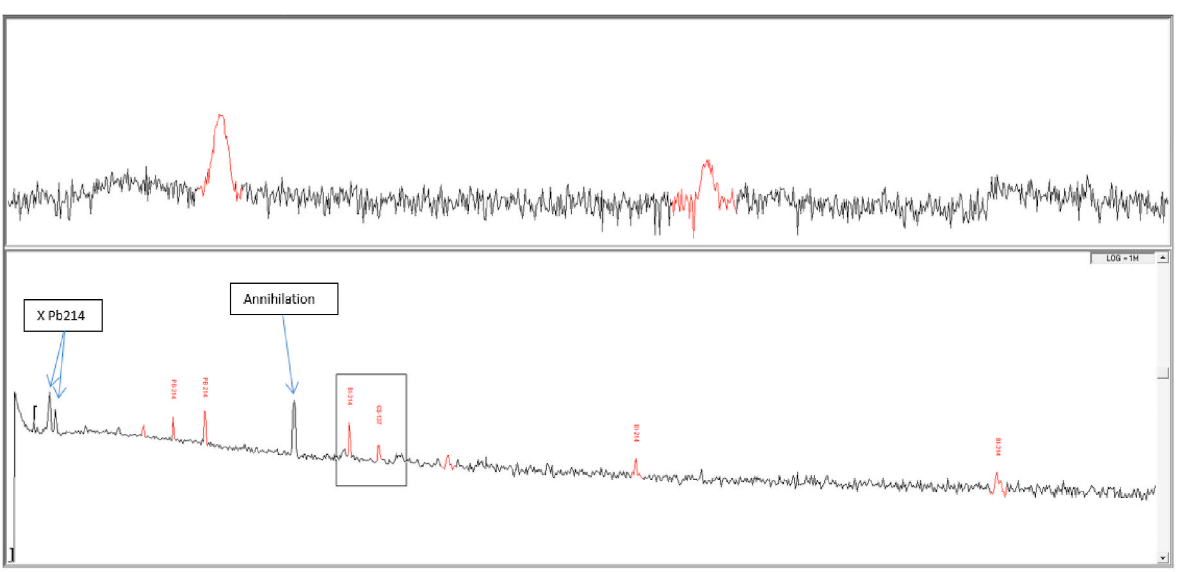

Fig. 6. Raw gamma-ray spectrum of sample A.

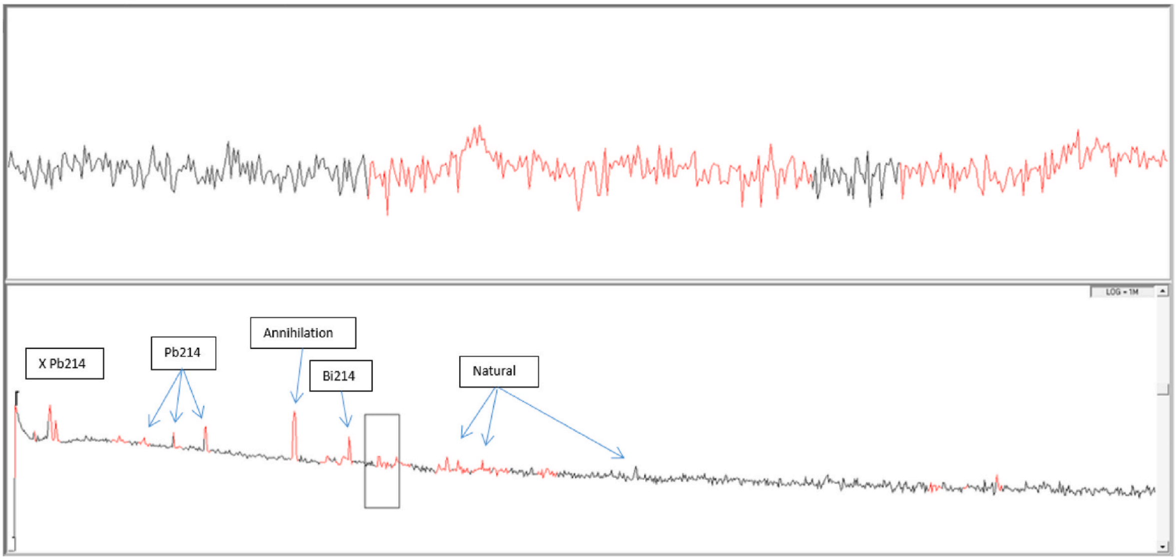

Fig. 7. Raw gamma-ray spectrum of sample B.

the non-standard geometry of the sample.

The presence of ^{137}Cesium raises questions.

As it is not naturally present in the environment and given the estimated magnitude of the energy of the phenomenon calculated previously, the first legitimate question is whether this phenomenon could be the source of the accumulated cesium on the bark.

Attempting to answer this question requires the study of other hypotheses. ^{137}Cs is an anthropogenic radionuclide (half-life = 30.17 years) known to result from fission in nuclear power plants or nuclear tests [10,11].

These two potential sources are discussed here. In terms of their possible exposure to radiation.

6.4. *Possible contamination from a nuclear power plant?*

In 1966, fourteen nuclear power plants were in operation in the US [12]. Without a major nuclear accident before 1966, like the one in Chernobyl (Ukraine, 1986) or in Fukushima (Japan, 2011), there is no possible contamination of ^{137}Cs.

6.5. *Contamination from nuclear tests?*

We need to consider only the global fallout between 1945 and 1966, as the sample was kept in a box and inside a house, protecting it from subsequent fallout after being collected. The deposition of atmospheric ^{137}Cs started around 1952, with measurable global fallout observed by 1954. The initial peak in fallout levels occurred in 1959, followed by a second peak in most regions around 1963 [13,14]. Nevertheless, the deposition of ^{137}Cs is not well documented in 1967. However, it is possible to reconstruct the deposition pattern of ^{137}Cs using the Strontium-90 (^{90}Sr) data. The production rates of these two radionuclides (fission yields) are well known, and it has been established that there is no fractionation between them during atmospheric transport [15]. The production rate for ^{137}Cs in fission weapon tests is 1.6 times

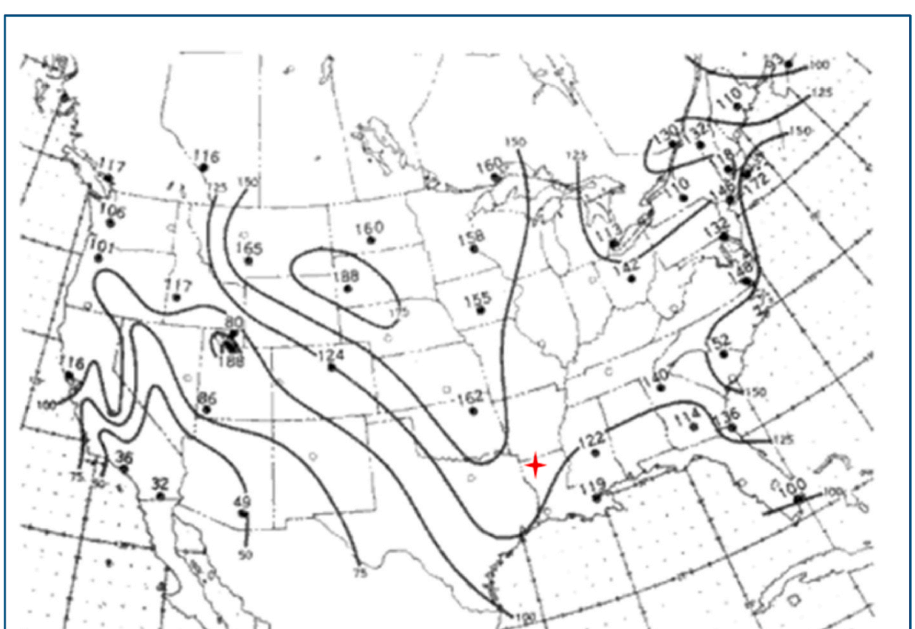

Fig. 8. Strontium-90 in soil in 1963 and early 1964 in the continental US and southern Canada, millicuries per square mile. (from Alfred W. Klement, 1965).

higher than that of ^{90}Sr [16]. Studies conducted in the late 1940s identified ^{90}Sr as the most dangerous radionuclide in fallout due to its biological accumulation in bones and the associated risk of bone cancer. Because of its significance, ^{90}Sr deposition has been monitored globally. These data were used to create a map of cumulative ^{90}Sr deposits in 1965 (Fig. 8).

Localization of Haynesville at the red cross.

From this map, it is possible to estimate the ^{137}Cs deposit in the US in 1964.

To convert milicuries per square mile in Bequerel per square meter we use:

$$\text{Bq m}^{-2} = \text{mCi mi}^{-2} \times 3.7 \times 10^{7} \text{ Bq mCi} \div 2.59 \times 10^{6} \text{ m}^{2} \text{ mi}^{-2}$$

$$\text{Bq m}^{-2} = \text{mCi mi}^{-2} \text{ x } 14.278$$

$$\text{Bq m}^{-2} (^{137}\text{Cs}) = \text{mCi mi}^{-2} (^{90}\text{Sr}) \text{ x } 14.278 \text{ x } 1.6 \quad \text{(eq.8)}$$

From the isoline of activity shown in Fig. 8, we can assume that the activity of ^{90}Sr in the soil in Haynesville in 1964 was about 137 mCi mi^{-2}.

By applying the coefficient displayed in (eq. (8)), two years before the UAP event in Haynesville, the activity is around 3141 Bq m^{-2}.

We will keep the order of magnitude 3000 Bq m^{-2} in December 1966. We could therefore assume the ^{137}Cs on the blackened bark was from the global fallout if it was clearly detected on sample B. Which is not the case.

6.6. *Sample examination*

When we examine sample A, we might expect to see only the outer surface blackened, as we know that only this side was exposed to the phenomenon/object. This is not the case, both the outer and inner of the sample are blackened while the interior remains unaffected. It is on that basis that more accurate estimates of energy could be made, as we will summarize in the following sections.

7. Energy considerations

High-energy events are not rare in the context of UFO/UAP reports. They are often noted to impact both human health and physical devices in consistent ways.

Among the latter effects are injuries to the central nervous system, to the skin and the eyes, as well as long-term conditions that occasionally require hospitalization and can lead to death.

Physical impact (apart from known mechanical effects) is most often in the form of light energy (many cases trigger photocells in cities and villages) and detrimental impact on irradiated plants, as in this case.

As seen above, following the observation, the main witness and two other experts proposed estimates of the radiated energy, arriving at very high values, in the range of a small nuclear energy generation facility.

7.1. *An Alternative formulation*

Although we share the principle of the source power estimates of the previous paragraph (based on the comparison of the light intensity from the car headlights radiated on the surface of the road in front of the car, with the light intensity from the unknown source, radiated around the car), we propose to clarify assumptions and figures, based on the hypotheses leading to the equation of light transfer from the source to the ground surface.

Depending on assumptions, this might have an impact, increasing the estimated value of the unknown source power by a factor around 10.

Here we face two hypotheses.

- **Hypothesis 1:** an isotropic radiation from the car (as in the underlying assumption of the former analysis) and from the unknown source sphere of light.

In this case, each source is radiating in all directions, diluting the intensity by 4π (see Fig. 9).

- **Hypothesis 2:** the radiation from the car headlights is directive.

In this case all the power of the headlights is concentrated into the beam, while the unknown source is still isotropic. The equations of energy transfer are now different between the two sources, one directive, the other isotropic (power divided by 4 π).

We will assume the atmospheric transmission is equal to 1, without attenuation of the light, which puts the unknown source power radiated estimate at a minimum value.In case of atmospheric attenuation, the source power would be higher.

7.2. *Estimation of the car headlights intensity in front of the car*

The known radiated power *Pc* from the car is 150 W.

The incoming power intensity Ic (also called 'radiance') is the surface density of power per surface unit (W/M^2), radiated from the sources such as car head lights or unknown source, down to the surface in front of the car.

We recall that the observer noticed that the intensity of the unknown source was *brighter* than the light from the car.

In hypothesis 1, the car headlight power is totally radiated around (Fig. 9)

With:

R_c (m): distance from the car to the area where the intensity from the car headlights and the source overlap and equalize,

R_s (m): distance from the source to the area where the intensity from the car head lights and the source overlap and equalize,

P_c (W): car light power,

P_s: Power of the source,

I_c (W/m2): Car light "intensity" (radiance of incoming light)

I_s (W/m2): Unknown source "intensity" (radiance of incoming light from source at the place of observation where car light and unknown-source light flux overlap.

Under this assumption, the equation giving Ic is the power density in the surface S1. It is given by P_c/R_c^2

$$I_{c=\frac{P_c}{4\pi.\ (R_c)^2}} \quad \text{(eq 0.9)}$$

In hypothesis 2, the car headlight power is entirely focused inside the headlight beam (Fig. 10).

The intensity (Is) is given by the same equation while the total power of the headlights *Pc* remains in the solid angle made by the S $_1$/Rc 2 source ratio.

$$I_{c=\frac{P_c}{(R_c)^2}} \quad \text{(eq. 10)}$$

With:

R_c (m): distance from the car to the area where the intensity from the car lights and the source overlap and equalize,

R_s (m): distance from the car to the area where the intensity from the car lights and the source overlap and equalize,

P_c (W): car light power.

I_c (W/m2): Car light "intensity" (radiance of incoming light)

I_s (W/m2): Unknown source "intensity" (radiance of incoming light from source at the place of observation where car light and unknown source light flux are overlapping.

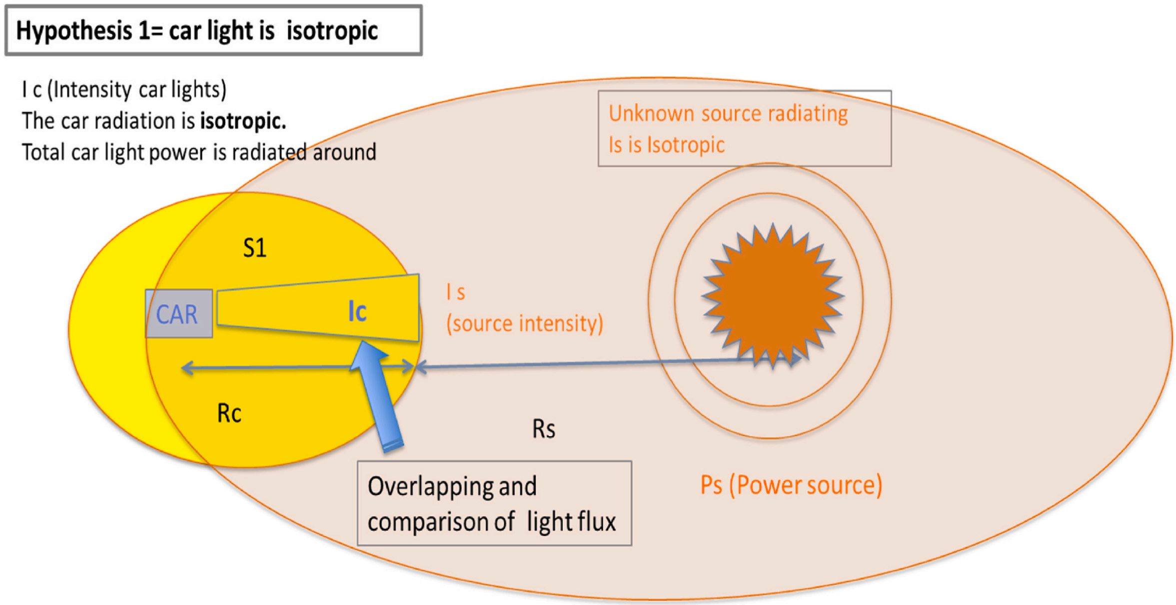

Fig. 9. Hypothesis 1.

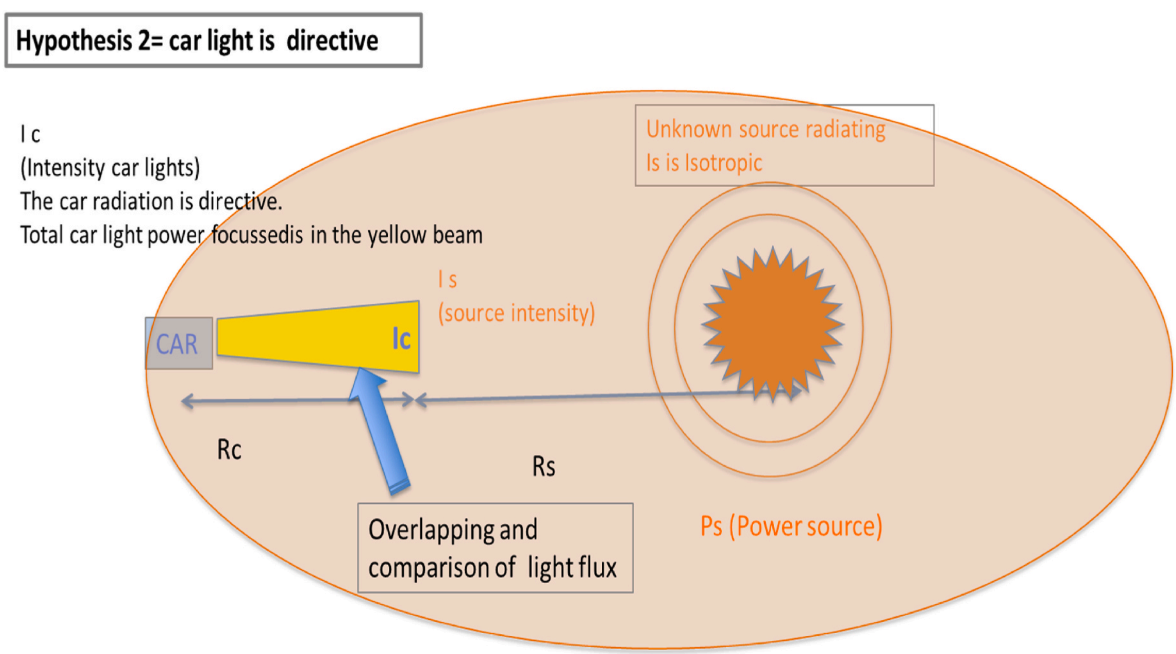

Fig. 10. Hypothesis 2.

7.3. *Unknown isotropic source intensity radiated close to the car*

For the unknown source, the assumption is different. We can suppose the sphere is radiating an isotropic energy flux on 4π steradian (sr).

This means that the light is radiated homogenously on a sphere in any direction from the source as shown in both hypotheses (Figs. 9 and 10).

The equation used is the same as for the headlight Intensity Ic in Hypothesis 1.

This intensity in W/Sr is projected on the surface S_2 in front of the car at the distance Rs source from the sphere). If we look at the intensity Is of this light per surface unit (to be divided by S_2) the value is obtained by the following equation.

$$I_s = \frac{P_s}{4\pi.\,(R_s)^2} \quad \text{(eq. 11)}$$

According to testimony, we can assume that the intensity of the unknown source is brighter than the light from the car, by a factor of alpha (we can take alpha = 50 or 100).

$$I_s = \alpha.I_c \quad \text{(eq. 11)}$$

Depending on the hypothesis, we can then compute the estimate of Ps versus *Pc*:

$$\text{Hypothesis 1}: P_s = \alpha.\,P_c\,.\left(\frac{R_s}{R_c}\right)^2 \quad \text{(eq. 12)}$$

$$Hypothesis\ 2: P_s = 4\pi\alpha.\ P_c\ .\left(\frac{R_s}{R_c}\right)^2 \quad \text{(eq.13)}$$

R_s is the distance between the unknown source and the vehicle, namely 2400 ft (732m) or 1800 ft (550 m)

We can then make an estimate of the unknown source power at both distances, while varying the value of the alpha parameter, as given in the following tables.

- In the case of Hypothesis 1 (isotropic car light):

Alpha (m)	P car lights (W)	Rs (m)	Rc (m)	Ps source (kW)
10	150	550	3	50,417
10	150	732	3	89,304
50	150	550	3	252,083
50	150	732	3	446,520
100	150	550	3	504,167
100	150	732	3	893,040

- In the case of Hypothesis 2 (directive car light):

Alpha (m)	P car lights (W)	Rs (m)	Rc (m)	Ps source (kW)
10	150	550	3	633,233
10	150	732	3	1,121,658
50	150	550	3	3,166,167
50	150	732	3	5,608,291
100	150	550	3	6,332,333
100	150	732	3	11,216,582

In summary:

The former estimate of the Unknown source power Ps was made according of simplified assumptions based on Hypothesis 1 (isotropic sources). It leads to a power estimate around 500–900 MW for alpha equal to 100, or 250–550 MW for alpha equal 50. This range of values is similar to the previous analysis, but it represents a minimum value assumption.

A directive car headlight radiation seems more realistic. It leads to higher power estimates.

We also note that we have assumed no attenuation from atmosphere, a fact that also minimizes the source power estimate.

8. A new approach: investigating the characteristics of the source

In this section, we aim to build on the initial assessments provided by the Condon Report by introducing a numerical thermal diffusion model that simulates heat transfer in the bark of the trees affected by the unknown light source.

The goal here is to refine the energy estimates of the source, leveraging modern techniques and data that were unavailable during the original investigation.

8.1. Basis for a new energy model

The Condon Report provided an estimate of the source's power based on comparisons with car headlights, calculating energy outputs in the range of 500–900 MW. However, these calculations were based on witness testimonies and basic physical approximations. The exact details, such as the duration of the light pulse, the distance between the source and the bark, and the number of trees affected, remain uncertain.

In the decades since the event, advances in computational methods allow us to construct more detailed models of how the energy from the light source interacted with its environment.

Specifically, our focus is on the charred bark found on trees in the clearing where the light was observed. Understanding how this bark was charred will allow us to constrain the source characteristics more precisely.

8.2. Thermal diffusion solution

To address these uncertainties, we have developed a one-dimensional (1D) thermal diffusion solution to simulate the propagation of heat through the bark of the trees when exposed to an intense thermal radiation source.

This numerical model solves the heat diffusion equation using an explicit finite difference method with appropriate time and space discretization (Courant-Friedrichs-Lewy [CFL] condition) to ensure stability and convergence:

$$\frac{\partial T(r,t)}{\partial t} = D\frac{\partial^2 T(r,t)}{\partial^2 r}$$

with.

- $T(r,t)$ the temperature as a function of radius and time
- $D = \kappa/\rho C$ the thermal diffusivity of the bark (which incorporates its thermal conductivity κ, specific heat capacity C, and mass density ρ)
- r the distance from the heat source.

The unknown source is assumed to be isotropic and the heat propagation in the bark spherical (a reasonable approximation given the radial symmetry of the clearing).

We suppose that the trees in the clearing were shortleaf pine, a species identified in the area. Shulga et al. [17] give the chemical composition of bark for different wood species, pine bark being composed at 67.4 % of lignin (Table 1).

The chemical formula for lignin is C81H92O28, from which we can derive an approximate x-ray attenuation length spectrum (Fig. 11) by making use of the Henke X-ray attenuation database [18] and considering an average mass density for the bark of 497 kg.m−3 [19].

Under those conditions, the data shows that any bark sample thicker than a few microns is optically thick to photons of energy < 1 keV.

We will here disregard any potential non-local radiative transport effect and assume that, in this context, the incident radiation from the source is totally absorbed at the surface of the bark (optically thick approximation).

The initial conditions for the bark are

$$T(r,0) = T_{ambient} = 20^{\circ}\text{C (293 K)}$$

and the boundary conditions at the inner radius of the clearing

6000 to 11,000 MW for alpha equal 100,

3000 to 5600 MW for alpha equal 50,

600 MW to 1100 MW for a low value of alpha (10).

Table 1
Chemical composition of bark. Source: Shulga et al. [17].

Wood species	Moisture, %	Ash, %	OCH, %	Cellulose, %	Lignin, %	Extractives, %, Soluble in	
						Hot water	Organic mixture
Pine	6.9	2.4	2.4	18.1	67.4	1.7	19.7
Spruce	6.9	2.1	2.5	21.8	44.8	2.9	12.7
Birch	6.3	4.3	5.1	25.2	40.0	9.5	3.9
Aspen	5.9	4.2	3.6	22.1	26.6	9.6	8.0

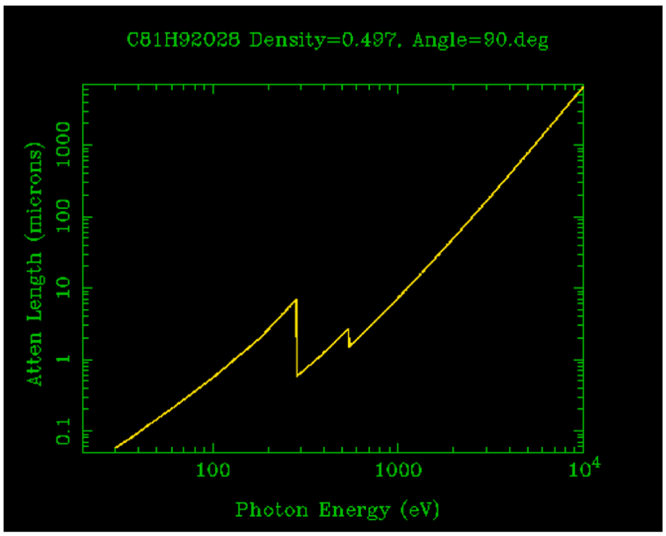

Fig. 11. Attenuation length spectrum for lignin at 497 kg/m^3 [18].

$$\kappa \frac{\partial T}{\partial r}\bigg|_{r=r_{in}} = I_{source}$$

with I_{source} the radiative intensity received by the bark surface from the source (Eq. previous section 6#).

In this first iteration of the model, the bark thermal conductivity and heat capacity dependency on temperature and density are disregarded and their ambient values ($\kappa = 0.016$ W/m/K and $C = 1369.0$ J/kg/K [19]) are used. The material is also considered to remain static and the advection equations not solved for. These assumptions are debatable as substantial phase changes and radiative ablation could be expected at some of the power levels considered. We assume the bark's threshold for charring is 300 °C (Matsuyama et al. [20]).

8.3. Preliminary results and challenges

By running simulations, we can explore the conditions under which the light source would have produced the observed heat damage.

For instance, Fig. 12 shows the simulated evolution of the thermal wave and charred thickness inside the bark for an ideal flat-top source of 500 MW emitting for 1.5 s (matching witness estimates) from an altitude of 20 m above the center of the clearing.

For the entire duration of the radiative pulse, the temperature of the tree surface increased from 293 K to 762 K as the thermal wave diffuses through the bark.

It takes several seconds after the source is extinguished for thermal equilibration to settle. The final thickness of carbonised material is around 250 μm which could be consistent with the recovered wood samples.

This seemingly good agreement with the Condon Report's estimates is misleading, however, as the parameters are adjusted to match the observation. One of the key challenges in this approach is the dimensionality of the problem, the thermal diffusion solver creating a 3D parameter space that depends on source power, pulse length, and distance to the bark.

This model allows us to simulate different combinations of these parameters to find values that would reproduce the observed charred bark. However, the simulation alone does not provide a definitive solution—only a range of possible values based on different assumptions.

The solution space is complex and currently contains multiple unknowns including:

- The position of the source: the altitude and relative position of the source is unknown, which limits our ability to fully constrain the source's distance to the trees.
- The duration of the pulse: the duration of the light pulse is based on witness estimates, which could be inaccurate.
- The impact of the simplification to 1D: the model does not account for lateral heat conduction or edge effects, which could influence temperature distribution.
- The number of trees affected: we do not have precise data on how many trees were affected or the exact radius of the clearing.
- The opacity of the atmosphere to thermal radiation: the model assumes an optically thin atmosphere, neglecting absorption and scattering due to fog, rain, and tree foliage. Incorporating atmospheric attenuation would require the source power to be higher to achieve the same heat flux.
- Variability in bark conditions: moisture content, bark heterogeneity, phase changes and temperature can affect thermal properties.
- The extent of the charring (maybe one of the most crucial ones): without detailed information on the depth and uniformity of the charring, it is difficult to fully validate the approach or reduce the dimensionality of the problem.

9. Recommendations for further work

Given the time elapsed since the 1966 Haynesville incident, it is uncertain whether physical samples from the affected trees are still available. However, if any preserved samples exist, they could provide valuable data for refining our energy estimates of the anomalous light source. Should such samples be accessible, a detailed re-examination using modern analytical techniques is recommended.

Some logical steps in future research could include:

Forestry and botany specialists: provide expertise on the physiological responses of trees to intense heat and the interpretation of damage patterns.

Laboratory simulations: replicate the thermal exposure in a controlled environment using high-intensity light sources or lasers to observe the effects on bark samples, validating the thermal model and EOS.

Systematic sampling: collect bark and wood samples from trees at various distances and orientations around the clearing. This spatial distribution will help map the gradient of thermal effects and better estimate the energy dispersion.

Vertical profiling: obtain samples from different heights on the trees to assess how the thermal effects vary vertically, which could provide insights into the source's altitude and emission pattern.

Diverse species analysis: include samples from all tree species present to account for differences in thermal properties and charring

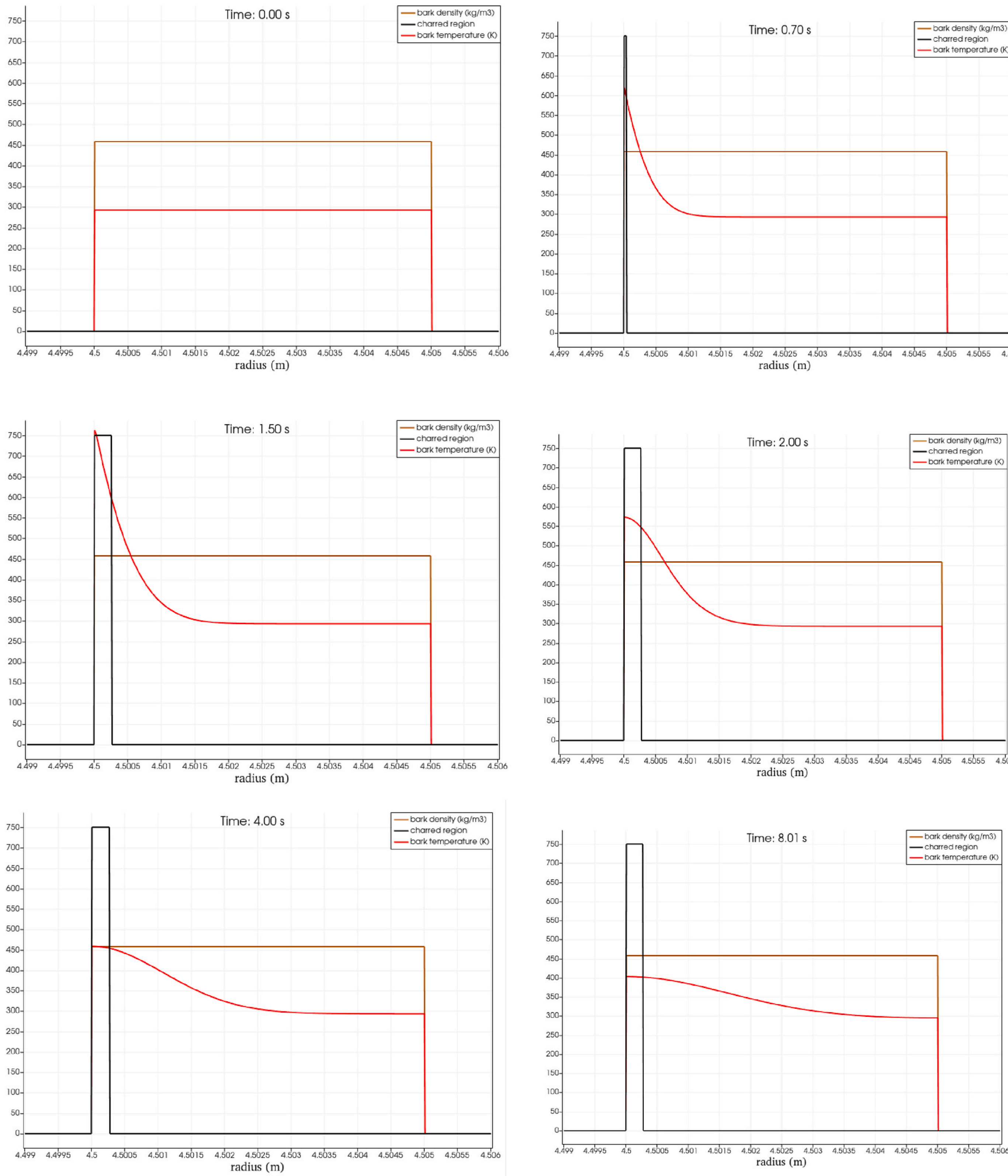

Fig. 12. Simulated evolution of the thermal wave and charred thickness inside the bark for an ideal flat-top source of 500 MW emitting for 1.5 s (matching witness estimates) from an altitude of 20 m above the center of the clearing.

thresholds, ensuring the results are not biased by a single species' characteristics.

Thermal property measurements: conduct laboratory tests to accurately measure the thermal conductivity, specific heat capacity, and density of the collected samples under conditions similar to those during the event.

Microscopic examination: Use microscopic and spectroscopic techniques to study cellular and structural changes in the bark, providing clues about the heating rates and maximum temperatures achieved.

Optical thickness consideration: Adjust the thermal diffusion model to account for the atmosphere's optical thickness, especially given the fog and drizzle reported during the event.

Pulse duration variations: Run simulations with a range of pulse durations (e.g., from 0.5 to 5 s) to determine how the duration affects the heating of the bark and the required source power.

Emission patterns: Model the source with different emission patterns (isotropic, anisotropic, directional beams) to evaluate how these affect the energy distribution and observed effects.

2D and 3D modelling: Expand the thermal model to 2D and 3D to capture lateral heat conduction, edge effects, and the spatial arrangement of trees and other environmental features.

Coupled thermal and advection equations: Account for potential ablation processes during the pyrolysis in the bark.

Sensitivity analysis: Identify which variables (e.g., thermal properties, atmospheric conditions, source parameters) have the most significant impact on the results to prioritize areas for precise data collection and refinement.

Advancing our understanding of the Haynesville incident requires a multifaceted approach that combines meticulous analysis of any available physical evidence, detailed reconstruction of environmental conditions, and sophisticated computational modelling.

By developing better equations of state for the vegetation materials involved and refining the thermal diffusion simulations to include variable parameters and multi-dimensional heat transfer mechanisms, we can achieve more accurate estimates of the energy emitted by the anomalous light source and reduce the dimensionality of the problem.

While the passage of time poses challenges, the application of modern analytical techniques and computational resources offers a promising avenue to shed new light on this enduring mystery.

10. Summary and conclusion

The Colorado University team closed its 1967 study of the case with the observation that the power amount was

> "enhanced by the effect (of reflection from cloud cover–JV) and attenuated by the rain, fog, and obstructing trees. And it impinged on the roadway at an unknown–really undefinable–angle. In such circumstances, photometry is crude indeed. Interpretation of even such a result as this in terms of the power dissipated in the light source introduces further wide uncertainties, since nothing whatever was known as to the mechanism of the light source or its radiative efficiency as compared with that of automobile headlamps, or whether it was radiating in a beam toward the witness or in all directions. All of these factors bear crucially on the power estimate, so that the value of several hundred megawatts is indeed dubious."

While these cautionary points were relevant, the ability to study the tree bark brings additional factors into play, which were not available to the Condon team at the time.

The research conducted by the main witness and his collaborators, and our own subsequent analyses, show that the case was not unique, contrary to the initial assumptions by the Condon team: at least two other unexplained, *unreported* incidents were discovered, namely the Taylor and Cockerell sightings of high-intensity white light sources, dated within days of the main event.

Reports of high-energy UAP observations are rare but not absent from official files.

(A) On August 27, 1966, a squadron of four Royal Canadian Air Force planes (Sabre F-86) flying at 36,000 feet observed and photographed "a bright light sharply defined and disk-shaped" that appeared "shiny silver" and sat horizontally below the plane's altitude but above the lower layer of clouds. It was "considerably brighter than sunlight." The observation lasted between 45 s and 3 min, depending on later estimates.

In that case, US Navy physicist Dr. Bruce Maccabee was able to derive the radiance from standard photographic formulas and found that, assuming the object was a Lambertian emitter with constant emittance over its surface, the power output within the spectral range of the film was in a very wide range of 2500 MW (equivalent to a typical nuclear power plant) to a value ten times greater (private communication), as is the case in the Haynesville observation) [21].

(B) The French files of the CNES organization monitoring reports of UAPs in France contain one case dated June 19, 1978, when several independent witnesses in the town of Gujan-Mestras (near Arcachon) saw a very bright object at night, the light of which triggered the town's night illumination as the light of day.

Knowing the threshold at which the detector was set, and depending on the actual distance of the light, which the CNES was not able to establish with precision, the power output in that case was estimated between 0.16 and 5.0 MW [22].

Knowing that such events are not unheard of, and that it is possible to derive energy estimates in such a high (and potentially dangerous) range, should encourage us to seek more reports of this type in US and foreign files. Such calculations can also provide us with important information in the design of future detectors for the phenomenon, as currently planned in several American projects.

CRediT authorship contribution statement

Jacques F. Vallée: Conceptualization, Formal analysis, Investigation, Project administration, Writing – original draft. **Luc Dini:** Formal analysis, Writing – review & editing. **Geoffrey Mestchersky:** Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to express their sincere gratitude to Dr. Nicolas Niasse for his invaluable contributions to the development of the computational models and the insightful discussions that significantly enhanced the analysis presented in this paper. His expertise was instrumental in shaping key aspects of this work.

Data availability

Data will be made available on request.

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