# Astronomy for Cloudy Nights

# Astronomy for Cloudy Nights:

## *Eight Essays of Respite from Frustrating Skies*

By

David Clarke
MSc PhD FRAS MinstP CPhys
Honorary Research Fellow
Emeritus Reader of Practical Astronomy
The University of Glasgow

Cambridge
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The front cover '*Cloudy Moon*' image was taken by the Author at midnight on the 5th of November 2022

# Contents



# Prologue

## Setting the Style

Annoying frustrations for a Professional Astronomer, and indeed for anyone who has a telescope, are '*Cloudy Nights*'. Having travelled to established sites which claim to have a large percentage of clear skies, the author still experienced a fair share of cloudy night problems.

Many books written on the basics of Astronomy for lay people and potential amateur astronomers include descriptions of the night sky with instructions for the use of a planisphere, binoculars or a telescope to find some of the more famous celestial objects. Good intentions for exploring the skies, at all levels of expertise, can be thwarted as the skies are not always clear after an observing plan has been prepared in readiness for a session at the telescope. Even for a professional astronomer, the same frustrations of cloudy skies can ruin intended research work. This was the experience of Agnes Mary Clerke, the Irish prolific writer and commentator on the development of Astronomy in the late nineteenth century.

Through correspondence and personal meetings, she made friends with the leading astronomers at home and in the USA. Invariably she wrote to her contacts to make sure that her interpretations of their works were correct and in order. Her book of 1881 entitled '*A Popular History of Astronomy during the Nineteenth Century*' received universal acclaim. At this time, despite all her writings, she had never used a telescope.

David Gill, Her Majesty's Astronomer at the Cape of Good Hope Observatory, suggested in a kind way, that her lack of a critical perspective of practical work showed in her writings. Eventually she was persuaded in 1888 to join him in South Africa to undertake some stellar observations.

She did succeed in obtaining some results which were published. Her report [*The Observatory*, **12**, 134-136, (1889)] opened with the: lines

> "Owing to the exceptional cloudiness of the weather,
> my gleaning in the Southern Skies were but scanty
> during the last week of my stay at the Cape."

Later, she sent a letter dated 5 January 1890 to her friend, Dr Edward Holden, Director of the Lick Observatory. It included the comment:

> "For the first time in my life I used an astronomical telescope, but my practice with it was deplorably impeded by cloudy weather the miseries of which torment I at least learned fully to appreciate."

I know the feeling well!

There have been several occasions, even at the best sited observatories, when my telescope nights were curtailed by bad weather. My worst experience relates to an award of telescope time at the Roque de los Muchachos Observatory on La Palma in the Canary Islands. As it happened, the dates for the research coincided with a significant Atlantic depression. In the first place, the beginnings of the storm affected the flight take off from Glasgow to Gatwick in London with snow on the runway. By just a few minutes, I was able to make my continuing flight, but the arrival in the Canaries was put into chaos by a diversion to landing on Grand Canary instead of Tenerife, where I had been due to take an onward flight to La Palma.

After a two-day frustrating delay of trying to recover my journey, I managed to take a catamaran ferry to Tenerife and then the La Palma flight. Thinking that I had lost the first night of my intended observations, I learned that the storm had prevented operations for all the telescopes on the site. This was fairly obvious as one-metre-long horizontal icicles adorned the observatories' door lintels leading to the domes. The next three nights were ruled out for telescope work by raging winds and thick cloud enveloping the whole of the site. For the last two nights, just a few hours were available to obtain meaningful data. All in all, about six hours were utilised out of the seventy that had been allocated for my research!

It was through such times of frustrating cloud cover that the seeds of writing this book were sewn. On several occasions, while anxiously waiting for the stars to appear, I joined observers from the various on-site telescopes to gather in a warm room and discuss Astronomy—not just talking about their stymied researches—but discussing wider aspects of the subject.

An example of a covered topic might be an occasion in the past when the subject was advanced by a breakthrough made by a now famous Astronomer. Geeky topics might be aired such as how the '*Mars Bar*' got its name. Some conversations covered topics in a seemingly random progression, being more fanciful and sometimes surreal—but usually connected to Astronomy in one way or another. The cloudy night occasions were always entertaining, and time appeared to pass quickly.

Although not exactly related to Astronomy, on one frustrating night, the support technician revealed plans for his upcoming retirement. He hoped to establish a Croquet Club at a hotel in Andorra with the aim of attracting business people to recuperate from their stresses. If nothing else, he could claim the venue as the world's highest for playing the game. The internet reveals that there is now a well-established club there, but I couldn't find his name attached to it.

On some occasions, I put pen to paper, jotting down a few notes based on cloudy night conversations to make the beginnings of a collection of ideas for writing a book. These included the works of Ancient and Modern Writers, Poets, Artists and Musicians.

Also recorded were Quotations and Anecdotes, with some based on personal experiences of working at various locations around the world, including at high altitude in the Bolivian Andes.

I also jotted down ideas related to some of the astronomical connections linked to everyday language and social interactions. My intention of expanding on all these scribbles is partially fulfilled in this text.

Unlike the profligate production of books introducing Astronomy to the lay person or budding amateur astronomer, the text here avoids the hackneyed progression of descriptions for the reader to gain familiarity with the night sky. Nor do the pages employ the overused format of describing the various kinds of object within the Universe according to their increasing distances from the Earth.

The contents of such books are often backed up by descriptions of the Moon, Sun, the Solar System with its Planets, Asteroids and Comets, the family of Stars, exotic objects such as Pulsars and Black Holes, our Milky Way Galaxy, and Galaxies at the extreme edge of the Universe. This is not the approach and style here.

Schemes normally follow object types according to increasing distances from the Earth. Presentations may also include up to date discussions on the origin of the Universe, referred to as the '*Big Bang*', and on its evolution by making reference to the enigmas associated with the search for '*Dark Matter*' and the mysterious force of '*Dark Energy*'. Again, this is not the approach of the book's Essays.

Some texts cover descriptions of ground based telescopes and the various kinds of appended instruments, all beyond the availability and capability of the regular amateur for recording and analysing the collected optical radiation. Radio astronomy with its large dish collectors or arrays of antennae may be described. Satellite projects may be covered which

extend investigations to other parts of the electromagnetic spectrum not available at ground level. Close up images may be presented of the beautiful atmospheres and rings of the gas giant planets, and of the rocky surfaces of the inner planets and the asteroids. Although there may be occasional comments relative to the above, again the current text avoids such a regularized approach.

Rather than the material following a continuous flow in a syllabus-like presentation, snippets of knowledge are provided following the form of my night-time conversations and meanderings—but with a subtle flow of connections, as happens in everyday life. Knowledge related to any subject can sometimes be gained in more random ways, and this is the approach made here.

As the themes are not progressive in the way other books appear to run, the text here provides a series of eight Essays rather than sequentially linked Chapters. The writing style and flow leads to more of a '*Bits and Pieces*' content, as described and interpreted further in the first Essay.

It isn't necessary to read the book's content sequentially from cover to cover. The Essays can be dipped into without following them from beginning to end, and they can be selected in any order. The overall text content is much broader than simply being directly related to Astronomy.

It is unique in that parts are autobiographical and carry personal anecdotes, but it is not wholly a memoir, as, at the same time, they carry leads to the underlying Astronomy.

Personal experiences of the author at the telescope are used to introduce astronomical topics, many of which are likely to be new to the reader. They give insight on the arduous, but joyous times when operating large telescopes. Also my aim is to pass on some unfamiliar aspects and knowledge of Astronomy which have captured my interest at various times.

Practical Astronomy has changed during the author's lifetime, with the advent of electronic computers, digital technology, satellite observatories and space missions. Without devoting a specific Section on these developments, they can be clearly seen within the text. They show how our views of the Universe have developed through improved efficiencies and accuracy of measurement with the collection of megabits of data over 24/7 periods for months on end.

The writing style avoids the sequential boxed-type teaching of a broad subject by broken down presentations of prepared small packages to be studied in turn, and learned with a following assessment. Such an approach can lead to a constrained education. I do remember a first year

undergraduate student being puzzled as to why I had used a '*secant*' in a formula describing the effects of atmospheric absorption, altering the apparent brightnesses of stars.

After my lecture, he came to see me as he thought '*Trigonometry*' was a self-contained subject within Mathematics, only involving formulas for internal relationships between sines, cosines, tangents and their inverses. My use of a '*secant*' seemed to be '*outside the box*'. The usefulness of Trigonometry was revealed to him for the first time.

The text is not overly mathematical, but there is some arithmetic here and there. The level of the numerical calculations and of some of the background physics does vary and may be challenging at times. Also, some of the arithmetic is non-logical with 2 plus 2 not equal to 4, and, with some calculations, it uses the unfamiliar unit of the '*square root of a googol*'—all with explanations that are easy to follow, even if manipulating numbers is not the forte of some prospective readers.

Occasional references are given for follow up on some of the topics, but they are not exhaustive as would be required for a fully academic work. In some places, my enthusiasm for teaching no doubt will show through.

As well as presentations with discussion on the Science behind the Astronomy and Astrophysics, topics are mirrored by the inclusion of '*borrowed material*' through references to Philosophy, the Law, Simple and Amusing Poetry, Reflective Poetry, Fiction Writing, Pop Music, Classical Music, Opera, Paintings, Music, and Literature. It should be obvious that Astronomy has connections to Time Keeping and the Calendar. In addition, the text provides simple Quotations and Anecdotes that summarise some aspects of the subject.

Many of the references to '*Arty*' items, under the umbrella of the various subject headings above, have a wide enough interest to warrant easy reading for people interested in the relationships between Science and the Arts, but with only superficial knowledge of Astronomy.

As it turns out there are many astronomical connections to everyday life that mainly go unnoticed, and these will be enlarged upon, particularly in Essay 2 which covers terms within '*The Spoken Word*'.

With additional content of personal stories, and the occasional use of the author's teaching mode in describing unfamiliar underlying Science, this book stands apart. Although '*educational*' might be an off-putting word for describing parts of any text, elements of direct education are included. They are written in a light and sometimes in a humorous way—Education is combined with Entertainment.

The chief aim of '*Astronomy for Cloudy Nights*' is to provide interesting aspects of the subject for the reader to enjoy, particularly at times when the weather prevents direct participation. Hopefully inclement weather will not continue for a whole week without a break when observing sessions are planned. But the Eight Essays could provide nightly respite reading over such a period, with one Essay to spare.

As well as celestial objects being '*seen*' by their optical radiation, many produce signals in the radio region of the electromagnetic spectrum. As a result, the discipline of Radio Astronomy has developed to map the skies over a range of frequencies and to discover some remarkable objects such as Pulsars and Quasars. Observations made in this electromagnetic domain are not affected by cloud cover to any great extent, and some not even by rain. Why didn't I engage in research within Radio Astronomy and avoid Cloudy Night frustrations?

I cannot cover and describe all my times and experiences of working and teaching as a professional Astronomer. But I can say there is nothing to surpass the feelings of making an observation leading to a discovery of something completely new and not previously recognised. There were two or three times when I experienced such joys—not world shattering discoveries, but they helped the progress of some research lines in a significant way.

Much of the author's research was undertaken at observatories at exotic and/or remote locations around the world. Astronomy allowed exploration of foreign parts, some might be described as busy tourist magnets, others well off the beaten track. Many of my times and experiences have been sublime, others were quite scary. Stories of excursions between observing sessions are described.

An example was an exciting day when the author ran down and up the Grand Canyon in Arizona, which involved dealing with two unexpected emergencies. Later, after relating these and other experiences at various public lectures, at one presentation to a local Amateur Astronomical Society, I was introduced as the '*Indiana Jones of Astronomy*'. I am uncertain if the accolade is appropriate, and I leave it to the reader of '*Astronomy for Cloudy Nights*' to decide.

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# 1

# Bits and Pieces

*"Since you left me and you said goodbye*
*I'm in pieces, bits and pieces*
*All I do is sit and cry*
*I'm in pieces, bits and pieces."*

[Lyrics by Dave Clark & Mike Smith]

In my capacity as Director of the Observatory at Glasgow University, Scotland, I received many phone calls and letters each week seeking information on what the enquirer had seen in the sky. Also the questions asked were sometimes more of a general nature, seeking explanations about the workings of Astronomy. One letter I received from a lady simply read:

"Please tell me all you know about Astronomy.
I enclose a stamped addressed envelope."

From memory, my reply was courteous, but it was necessarily short—not because my knowledge is so little, but that the subject is infinite!

After a clear night, I would invariably receive phone calls the following morning asking questions about what someone had seen as possibly being unusual. Was it a UFO? Generally, my problem was one of interpreting the description of what was being reported before I could comment. An example of such a conversation might run:

"I saw this very bright star-like thing from my backdoor."

I would respond: "What time was this? In which direction does your door face?"

"I'm not sure."

I would then ask: "Was it in direction where the Sun sets?"

"Yes, I think so."

"I think you were likely looking at Venus."

"So it wasn't a UFO then?" . . .

Such phone interplays were fairly frequent showing that members of the general public were often unfamiliar with the simple aspects of the night sky. In aeons past, most people would be able to recognise the major constellations and where to find them by their calendrical connections. Part of the problem to-day is the erosion of our contact with one of the beautiful aspects of the natural world through the increase of light pollution by urban developments.

Other communications suggested that the '*Riddle of the Universe*' had been solved. One young boy claimed to have discovered '*Planet X*' after reporting it in his local newspaper. He had simply applied the Titius-Bode Law, established by Johann Daniel Titius in 1766 and promoted by Johann Elert Bode in 1772, and now generally referred to as Bode's Law. The Law expresses an empirical relationship describing the distances of planets from the Sun. Expressed in terms of the Earth's distance from the Sun, referred to as the '*Astronomical Unit*' (au), the first eight planets follow Bode's Law fairly closely. It can be written as:

$$D = 0.4 + 0.3 \times 2^n .$$

It shows that distances grow essentially by a factor of 2 for each planet in turn, according to its distance from the Sun. Mercury is a special case with $n = -\infty$ (minus infinity), giving $D = 0.4$ au. For Venus, $n = 0$, giving $D = 0.7$ au. For the Earth, $n = 1$, giving $D = 1.0$ au, exactly. Mars corresponds to $n = 2$, giving a value of $D = 1.6$ au.

Beyond Mars, Bode was conscious of there being a gap of any planet for $n = 3$ at $D = 2.8$ au. He wrote a footnote in his astronomical compendium:

"Can one believe that the Founder of the universe had left this space empty? Certainly not."

Some 25 years later, on the 1st of January1801, at his observatory in Palermo, Giuseppe Piazzi made a serendipitous discovery of an orbiting object at $D = 2.8$ au. It was given the name Ceres. In the following years a concentrated belt of similar bodies was discovered and they are referred to as '*minor planets*' or '*asteroids*'. Bode's Law is reasonably accurate for representing the dimensions of planetary orbits as far out as Uranus with its value corresponding to $n = 6$, giving $D = 19.6$ au. Other mathematical expressions have since been developed to encapsulate more accurately the relative distances of the planets from the Sun and for the relative sizes of

the orbits of their moons, but none are perfectly satisfactory. Returning to the young boy who thought he had discovered Planet X, he had done so just by setting n = 10 in Bode's Law.

Most enquiries were responded to in diplomatic fashion, but some letters, without reply, found their way into the Astronomy Departmental PoG file—named from a phrase in the Bible:

"And the Peace of God which surpasses all understanding . . ."

In addition to my teaching interests and research projects undertaken at Glasgow University, I promoted outreach activities of various kinds, long before '*public outreach*' became '*buzz words*' for such pursuits. These involved undertaking Extra Mural Classes both at the Observatory and also in towns some distance from the city, with winter journeys, and returning home in the late hours. Presenting talks to local amateur astronomical societies and other social groups were regular enjoyable occasions.

One memorable summer residential class, which I organised for teachers and educationalists, attracted a group with surnames nearly holding all the colours of snooker balls on the table. Participants and helpers included a Black and White, a Brown, a Blue and a Green. What are the chances of such an outcome from a group of just twelve people?

On Wednesday afternoons, I was free from undergraduate teaching and I provided time for visits by local Primary Schools. One of my innovations was a model of the Solar System with photographs pasted on to magnetic sheet material, and these were dispersed among the class. As the planets were called out in turn, the card holder would come forward and fix it on a large metal board according to its place in the Solar System. All the children had been primed at school with a mnemonic for the order of the planets out from the Sun—MVEMJSUNP.

I provided them with an alternative—**M**y **V**ery **E**arly **M**orning **J**am **S**andwiches **U**sually **N**auseate **P**eople—and someone in the class would invariably ask what does '*nauseate*' mean. On learning that it was a word for '*making people feel sick*', it caused great amusement. What is it with young children? Of course, **P**, is no longer included as it has now been designated as a '*dwarf planet*'.

It may be mentioned that the atomic elements, 92, 93 and 94, being Uranium, Neptunium and Plutonium respectively, were named after the planets Uranus, Neptune and Pluto.

About once a week I provided tours around the Observatory with telescope viewing and planetarium shows to various societies and organisations. One such visit was by a local Girl Guide group. Some fifteen

years later, I had a request for a tour and talk from the leader of the same group as she had pleasant memories of her earlier visit as a young girl. We were able to find her name in the Visitor's Book for that date. Just one of those simple things giving an emotional satisfaction from some of the enterprises undertaken in the past, proving them to have been worthwhile.

On one occasion, the University Council asked to have a night tour of the Observatory to inspect its facilities. Unfortunately, the skies didn't allow a view of the Moon. One question put me was:

"What is the possibility of there being other intelligent life in the Universe?"

My immediate quip was:

"We have a fresh intake of students each year and we are still looking."

From there I was able to talk about Drake's Equation, as it was then, dealing with the statistics of stars with possible planetary systems and the probability estimate for the number of advanced civilizations likely to exist in our Milky Way galaxy.

Within the teaching scheme for Glasgow undergraduate students in their third and fourth years, three practical and/or computational projects were required for completion with written reports. They were all devised by myself and were undertaken under my supervision. Of the many different ones over the years, four produced papers which were published in the appropriate professional journals. With authorship names attached, it was an excellent foundation for inclusion in student CVs following their graduation.

As for the undergraduate student community at large, one thing I enjoyed was the anarchy, sometimes even directed to myself. In the lecture room at the new Observatory at Acre Road, I installed model planets by fixing their supporting metal stalks into the plaster of the rear wall. Two scales were used for this 3-D model of the Solar System—one for the dimensions of the planets and one for the relative sizes of their orbits. If there had been a model of the Sun, it would have had a diameter of 1 metre, and the Earth would be placed at a distance of about 115 metres. The individual orbs originated from a previous University Observatory, but which closed in 1939.

They had been made much earlier, and prior to the discovery of Pluto in 1930 by Clyde W. Tombaugh at the Lowell Observatory in Arizona. When I took charge of teaching Practical Astronomy at Glasgow University, Pluto was still designated as a planet, but it was missing from the Observatory wall.

At the time it was not known that Pluto was accompanied by a nest of siblings—Charon, Nix, Styx, Kerberos and Hydra. In fact, little was known of its nature, not even its dimensions. It was thought to be covered by ice and that its full diameter was not seen, simply appearing as a bright point spot, this being the reflected image of the Sun in the centre of the planet's icy globe.

From a nominal estimate of its true diameter, on the scale of the Observatory's model, a half-inch polished steel ball bearing was ideal for its display. A spike was inserted in the wall and Pluto was attached by strong glue. For its location, it was placed at the end of the line of the other planets, but was hidden when the rear lecture room door was kept open.

Every winter, I delivered Extra Mural courses in Astronomy for the general public, and registration was always taken up to the occupancy limit of the lecture room. To provide air circulation during the evening sessions, its door had to be wedged open. At one of the presentations, I concentrated on the relative sizes of the planets and on their distances out from the Sun, using the models on the wall.

Towards the end of the lecture, I built up the description of what was known of the nature and size of Pluto and walked to the rear of the room to close the door and reveal its glory. The shiny orb with its central bright spot reflection of the room lights had gone. Pluto had been replaced by a dull brown chocolate '*Malteser*' much to the amusement of the audience. How could this be explained? Had the ice melted and was Pluto now covered by impenetrable clouds? Someone in the undergraduate class would have been overjoyed with their mischief.

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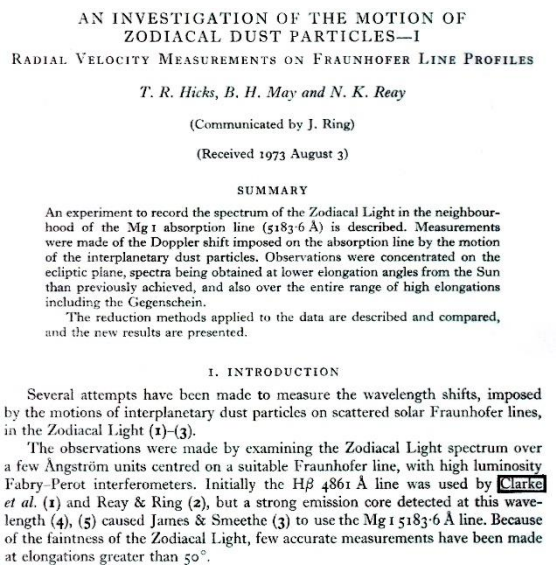
Following retirement, I continued presenting talks to various organisations. Depending on the makeup of the audience, particularly if they didn't have a background in Science, I tried to show how subjects are advanced step by step. This was done by projecting a copy of a paper[1.1] of 1974 by T.R. Hicks, B.H. May and N.K. Reay (see Fig. 1-1 on the following page). Its subject matter describes new observations recording the orbital motion of interplanetary dust particles around the Sun.

In the usual style of a scientific paper, its introduction provides reference to previous papers on the subject. Reference is made in the second paragraph to work performed by myself a few years previously at high altitude in the Bolivian Andes.



AN INVESTIGATION OF THE MOTION OF ZODIACAL DUST PARTICLES—I

RADIAL VELOCITY MEASUREMENTS ON FRAUNHOFER LINE PROFILES

*T. R. Hicks, B. H. May and N. K. Reay*

(Communicated by J. Ring)

(Received 1973 August 3)

SUMMARY

An experiment to record the spectrum of the Zodiacal Light in the neighbourhood of the Mg I absorption line (5183·6 Å) is described. Measurements were made of the Doppler shift imposed on the absorption line by the motion of the interplanetary dust particles. Observations were concentrated on the ecliptic plane, spectra being obtained at lower elongation angles from the Sun than previously achieved, and also over the entire range of high elongations including the Gegenschein.

The reduction methods applied to the data are described and compared, and the new results are presented.

1. INTRODUCTION

Several attempts have been made to measure the wavelength shifts, imposed by the motions of interplanetary dust particles on scattered solar Fraunhofer lines, in the Zodiacal Light (1)–(3).

The observations were made by examining the Zodiacal Light spectrum over a few Ångström units centred on a suitable Fraunhofer line, with high luminosity Fabry–Perot interferometers. Initially the Hβ 4861 Å line was used by Clarke *et al.* (1) and Reay & Ring (2), but a strong emission core detected at this wavelength (4), (5) caused James & Smeethe (3) to use the Mg I 5183·6 Å line. Because of the faintness of the Zodiacal Light, few accurate measurements have been made at elongations greater than 50°.

**Fig. 1-1:** Brian May's co-authored paper. The current Author's name has been highlighted.

I then asked who the second author of the paper might be.

Occasionally the response was that it was (Peter) May, the MCC cricket captain of previous years, so revealing the age profile of the audience. Eventually someone would shout out that it was the Brian May, more famous as the iconic guitar player of '*Queen*'. Brian opted out of research while at Imperial College in London when the group was formed. He never lost his passion for Astronomy and later returned to the researches of his student days to obtain a PhD degree in 2007 with a thesis entitled: '*A Survey of Radial Velocities in the Zodiacal Dust Cloud*'.

At this point I would show a cartoon (see Fig. 1-2) related to Professor Brian Cox, famed as a radio and television presenter. I then mentioned that his early career had been in music as part of the group '*D:Ream*'. They had several hits in the UK charts, including the number one, '*Things Can Only Get Better*', used as the anthem for New Labour in the UK Election of 1997. Although Brian played it on keyboard at gigs, he did not perform as part of the group's recorded track. I would also mention that Sir William Herschel, discoverer of the planet Uranus, played the organ and composed several pieces for the instrument.

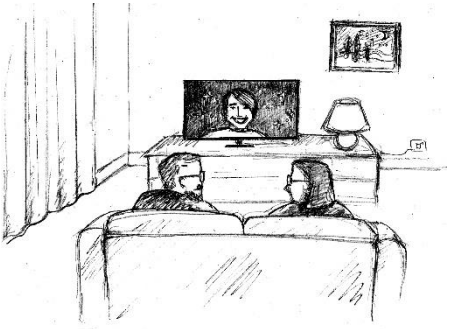


**Fig. 1-2:** "Professor Brian Cox has just shown us how black holes attract matter never to be seen again. When are you going to clean out and tidy your shed?"
Realism strikes home. The caption is very much down to Earth.
Have I heard similar things myself?

Questions frequently were then raised:

"Are there connections of being musical and having a 'scientific brain?"

and

"Is it necessary to be a musician or pop star to become an Astronomer?"

"Well I had a group once" was my response:

"Surely you have heard of the

**Dave Clark(e) Five**."

From there on, I was able to show a cartoon of the Astronomy staff of Glasgow University arranged in a stage setting similar to the Dave Clark Five. The sketch (see Fig. 1-3) was made by an anonymous second year student known as the '*Cosmic Scribbler*'. From left to right the staff were Archie E. Roy, John F.L. Simmons, the current Author, John C. Brown, later to become Astronomer Royal for Scotland, and Robin M. Green. As it turns out, the artist's observations were not quite correct, as I should have been the drummer and not the lead guitar player. Many other cartoons appeared on the notice board, all related to my lecture course (see later).


**Fig. 1-3:** The Cosmic Scribbler's signature is in the top right-hand corner of the Dave Clark(e) Five cartoon.

At the time of displaying the cartoon to a general audience, I would play the opening of Dave Clark's very recognisable and successful disc: '*Bits and Pieces*'. The repeated words, played out loudly, indicated the form of my presentation with some of the elements of Astronomy being linked to Poetry, Music and Art.

This style will be carried in my approach to the contents of the Essays making up this book, as may well have been appreciated already. For groups chiefly comprising ladies, in a way to introduce particular Astronomical topics, I would use songs from well-known musicals set up by myself and screened in Karaoke fashion for audience participation. '*Fly me to the Moon . . .*' was an excellent way to introduce a presentation on the seasonal changes on the Earth and Mars, and their lack on the planet Jupiter.

Another Cosmic Scribbler's cartoon was drawn following the author's lecture on telescope design. Including in my presentation were details on the reflection coefficients of the mirror coatings allowing calculation of an efficiency factor for transferring the telescope's collected light to its focus. Reference was made to the favoured process of vacuum deposition of aluminium on the mirror optical surfaces.

On presenting designs of spectrometers, it was mentioned that at the McDonald Observatory in Texas, some of the internal optics used gold coated mirrors. This was immediately thought to be ostentatious and was only done because Texas had the image of being an extremely rich State. Gold was chosen for a scientific reason because it has a better reflectivity in the infra-red relative to vacuum deposited aluminium.

While talking about instruments at the McDonald Observatory in Texas, I related the story of a '*crime*' in February 1970 involving the shooting of a telescope mirror. According to a version of the time, an employee of the Observatory had been sacked because of his alcohol problems. He later returned with a gun and fired a shot at his supervisor followed by shots at the 107-inch (2.7 m) primary mirror of the Harlan J. Smith telescope.

A conical pit of diameter about 1 inch was produced, so reducing the effective collection area by about ($\pi\, D^2/4 = \pi \times 1^2/4$) sq inches, making the overall collection aperture reduced marginally to being equivalent to that of a 106.995-inch telescope. The damage had no perceptible effect on the imaging quality of the telescope.

The Cosmic Scribbler's cartoon (see Fig. 1-4) appearing later was a parody of the story as I was shown with an axe, and about to attack a rich Texan. All the cartoons in my possession were signed as drawn by the

'*Cosmic Scribbler*' whose identity was never discovered. The artist obviously had great talent, and if a profession was made of it, I would be a rich holder of the early works. No matter who the Cosmic Scribbler was, I wished the student well with a future career, whether in Astronomy or any other field.


**Fig. 1-4:** The Cosmic Scribbler's cartoon of the Author poised to attack a rich Texan astronomer.

There is another story related to a defect in a telescope primary mirror. My fellow astronomer friend, Dr John F. Grainger, was overseeing the manufacture of an 80 cm telescope for an organisation in a middle eastern country. After grinding the primary mirror to its optical figure, a tiny pit was apparent in the polished surface resulting from a small bubble within the Cer-Vit glass. Its diameter was less than 1 mm.

Dr Grainger was asked by the optical company if he could relay the information to the managing recipient and ask if the mirror was acceptable, otherwise there would be a long delay for regrinding and refiguring the whole of the surface. The response was that the latter should be done. A question was posed as to what would happen if the light from a star of interest happened to fall within the pit so making it invisible. Something was lacking in the understanding of optics here.

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The link between perceiving nature, including the heavens, in its immediate awe inspiring impact on our emotions, and on the aspirations of a scientific mind, has been beautifully expressed by the Norwegian astrophysicist, Svein Rosseland. In the Introduction to his book '*Theoretical Astrophysics*' (Clarendon Press, Oxford, 1936) he wrote:

"Who has not experienced the mysterious thrill of springtime in a forest, with sunbeams flickering through the foliage, and the low humming of insect life? It is the feeling of unity with nature, which is the counterpart of the attitude of the scientist, analysing the sunbeams into light quanta and the soft rustlings of the dragon fly into condensations and rarefactions of the air. But what is lost in fleeting sentiment is more regained in the feeling of intellectual security afforded by the scientific attitude, which may grow into a trusting devotion, challenging the peace of the religious mystic. For in the majestic growth of science, analytical in its experimental groping for detail, synthetic in its sweeping generalizations, we are watching at least one aspect of the human mind, which may be believed to have a future of dizzy heights and nearly unlimited perfectibility."

A similar notion, although not quite carrying the same attitude to the scientist, is portrayed more briefly by the Scottish writer, Thomas Campbell (1777-1844) in his poem:

"When Science from Creation's face
Enchantment's veil withdraws
What lovely visions yield their place
To cold material laws!"

When we examine the ways our knowledge and understanding of Science advance, both in theory and by experimentation, with new laws promoted, they generally rely on immediate previous researches. Such a development is clearly seen in the introduction of Brian May's paper as displayed in Figure 1-1. As a philosophical concept, this was perceived centuries prior to Sir Isaac Newton, but he encapsulated it in a letter to Robert Hooke in 1675 when he wrote:

"If I have seen further it is by standingonthe sholders [sic] of Giants."

One of those giants for Newton was Johannes Kepler (1571-1630). It was he who established the fact that the orbits of the planets in the Solar System have elliptical form. With this discovery, Kepler encapsulated their orbital behaviour in his famous Three Laws. Briefly, without full explanation, they can be summarised as follows:

1. All planets have elliptical orbits with the Sun at one of the foci.
2. An imaginary line joining the Sun and a planet sweeps out equal areas in equal times.
3. The square of the time taken for a planetary orbit about the Sun is proportional to the cube of the semi-major axis length of the ellipse.

In a letter[1.2] to his son-in-law, Jakob Bartsch, Kepler's passion for his life work was summarised by writing:

> "If there is anything that can bind the heavenly mind of man to this dreary exile of our earthly home and can reconcile us with our fate so that one can enjoy living,—it is verily the enjoyment of the mathematical sciences and astronomy."

Kepler derived his Three Laws by using the huge collection of positional measurements of the planets made by Tycho Brahe. Brahe's records were sufficiently accurate to reveal the ellipticity of the planetary orbits and also the planets' speeds at different points along their orbital paths. Kepler published his first Two Laws in 1609 and the Third one in 1618. He believed there was some kind of force from the Sun which pushed the planets along, but he was unable to identify the mechanism.

Published in 1687, Sir Isaac Newton's '*Philosophiæ Naturalis Principia Mathematica*', referred to as the '*Principia*', presented the concept of '*Universal Gravity*'. It revealed that a pair of masses would be attracted to each other with a force which depended on their masses and the inverse square of their distance apart. Newton's work proved the validity of Kepler's Laws, and that two body orbits were '*conic sections*' with figures in the form of circles, ellipses, parabolas or hyperbolas. Usually in astrophysical situations, two body orbits follow the form of ellipses, as is the case for the planets of our Solar System.

There are some scientists who have visions in the form of pipe dreams, or pure speculations, of how things might truly be, but remain hidden from us. One such conjecture was by Sir Arthur Schuster, Professor of Physics at Manchester University, in what appears to be a whimsical paper[1.3] of 1898, judged by its title: '*Potential Matter — A Holiday Dream*'.

He considered the fact that many concepts in physics carry binate features such as magnetic north and south poles, and both positive and negative electricity. He suggested that there might be a kind of matter carrying repulsive gravitational properties. Coining the term '*anti-matter',* he considered the possibility of there being solar systems comprising such material which would yield energy when the anti-atoms coalesce with atoms of normal matter. His paper concludes with the single short question:

> "Do dreams ever come true?"

Although unrelated to the driving force behind the work of the British theoretical physicist Paul Dirac, Schuster's hypothesis achieved a kind of credence some thirty years later. Dirac produced an equation giving

solutions that he interpreted as predicting the existence of antimatter, with one particle being equivalent to the electron with identical mass, but with a positive charge. This particle, the '*positron*', was later detected from the behaviour of cosmic rays passing through a laboratory cloud chamber. Dirac shared the 1933 Nobel Prize for Physics with Erwin Schrödinger.

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Turning now to the relationship between metaphors, quotations and poetry with respect to Astronomy, generally it is the natural beauty of the skies, or our sense of exploration, that triggers the writer's pen. Not everyone agrees with the style and sentiments carried, however. Paul Dirac had no truck with it. A quotation of Dirac related to Science and Poetry in general sums up his position:

"In Science you want to say something nobody knew before in words which everyone can understand. In Poetry you are bound to say something that everybody knows already in words that nobody can understand."

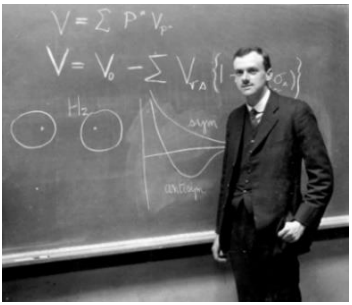

**Fig. 1-5:** Paul Dirac, Nobel Prize winner for Physics in 1933.

Vladimir Nabokov, the famous Russian/American novelist and author of '*Lolita*', in an interview[1.4] in 1967, countered any apparent conflict by saying:

"... I certainly welcome the free interchange of terminology in any branch of science and any raceme of art. There is no science without fancy and no art without facts ..."

Nabokov used Quantum Mechanics, Relativity and Classical Astronomy as metaphors in his novel, '*Bend Sinister*'.

The apparent rigidity of Science, as expressed by Dirac, is simply countered by the artist, Joseph Albers:

"In science, one plus one is always two; in art it can also be three or more."

Following the wrangles of non-logical arithmetic by philosophers and writers for well over 250 years, the famous astronomer, Sir Arthur Eddington, noted that:

> "We often think that when we have completed our study of 'one' we know all about 'two', because 'two' is 'one and one'. We forget that we still have to make a study of 'and'."

Non-logical arithmetic is better known by the equation: 2 + 2 = 5. This particular inequality has appeared in literature over the centuries. It was used by Gilbert and Sullivan in their operetta '*Princess Ida*' in 1884. Perhaps its notoriety is through its sinister use by George Orwell in his acclaimed work, '*1984*'. In the early part of this political novel, Winston Smith wrote in his diary that:

> "Freedom is the freedom to say that two plus two equals four."

Later he was charged as a '*thought criminal*' and interrogated in Room 101. Following his indoctrination on the ethos of the country's '*Party*', and his torture in the '*Ministry of Love*', he was mentally broken. Sometime after, as he sat at the Chestnut Tree Café, he drew out '2 + 2 = 5' on the dusty table.

The French novelist, Victor Hugo, could clearly see the connections between Astronomy and Poetry. In his autobiography[1.5] he wrote:

> "Astronomy, that micography of heaven, is the most magnificent of the sciences. . . . Astronomy has its clear side and its luminous side; on its clear side, it is tinctured with algebra, on its luminous side with poetry."

One of my favourite poets is Walt Whitman, an American writer. A work of his, given below, was published in 1865[1.6]. At a first read, I thought it must relate to one of his own experiences. It gives the feeling that some students may have when trapped in the confines of a lecture theatre. I am sure several readers at some presentation, not necessarily on Astronomy, might have had similar urges to leave because of speaker boredom, but would not have had the courage to walk out. The poem reads:

> "When I heard the learn'd astronomer,
> When the proofs, the figures, were ranged in columns before me,
> When I was shown the charts and diagrams, to add, divide, and measure them,
> When I sitting heard the astronomer where he lectured with much applause in the lecture room,
> How soon unaccountable I became tired and sick,
> Till rising and gliding out I wander'd off by myself,
> In the mystical moist night-air, and from time to time,
> Look'd up in perfect silence at the stars."

There is another interpretation to this, however. Whitman was a man who was passionate about Nature and felt that it should be '*experienced*' rather than '*measured*'. The poem is thought to relay his belief in the limits of Science to understand Nature. Instead of measuring it, Nature needs to be experienced for a true understanding, perhaps in solitude. In the poem, the anaphoric use of the word '*When*' seems to emphasise the lack of any emotional connection to Nature and appears to induce the boredom. In a sense he his expressing the difference between '*knowledge*', based on recorded facts and mathematical interpretation, and '*wisdom*' which comes from the experience of the simple observation of Nature.

Some people express challenges against the purpose of astronomical research, especially the cost of it all. Why do countries become involved with expensive space missions when many in their population are suffering abject poverty? Why bother with it as it has no practical use? Such expressions are not new. An early example of this attitude appears in a play '*Tis Pity she's a Whore*' written by John Ford in 1633. The word '*fond*' is an old word meaning '*foolish*':

"Such questions, you, are fond: for better 'tis
To bless the Sun than rather reason why it shines."

With a positive outlook, there are many more quotations and poems that provide inspiration for involvement in Astronomy. First of all, there are those which reflect our thirst for knowledge. A good example of this genre can be found through the poet Virgil (70BC-19BC) as in his '*Georgics - Book 2*' he wrote:

"Give me the ways of wandering stars to know,
The depths of Heaven above, and the Earth below;
Teach me the various labours of the Moon,
And whence proceed the eclipses of the Sun."

There is a well-known philosophical quote by Jean B. Perrin (1870-1942), the French physicist and Nobel Prize winner, which states:

"It is indeed a feeble light that reaches us from the starry sky.
But what would human thought achieved if we could not see the stars?"

I have heard it said that Sir Arthur Eddington, in a reflective moment, suggested that if we had been perpetually under clouds, we would never have seen the stars and would not have known of their existence, but they would have been invented by imagination through physics and mathematical theory.

There are many quotations reflecting our persistent curiosity and our drive to explore. Such sentiments can be interpreted from within the poem

'*Andrea del Sarto*' by Robert Browning (1812-1889). It simply advises that we should get involved in gaining knowledge of the Universe:

"Ah, but a man's reach should exceed his grasp
Or what's a heaven for?"

Carl Frederick Gauss (1771-1855) was a giant of Science, particularly in the field of Mathematics and Statistics. His formulation of the '*Normality Theorem*' remains a mainstay of modern data analyses. As mentioned earlier, the minor planet Ceres was discovered by Giuseppe Piazzi. From the early measurements of its movement in the sky, Gauss was able to determine its orbit and predict its position when it returned to the skies from behind the Sun, allowing it to be '*discovered*' for a second time. He was also involved with study of magnetism which shows through in respect to his passion for Astronomy within a letter[1.7] he wrote to Wolfgang Boyal in June 1803 saying:

"Astronomy and Pure Mathematics are the magnetic poles
toward which the compass of my mind ever turns."

Incidentally, in 1802, Gauss suggested that we could make our presence obvious to any Martian civilisation by clearing a large area in the Siberian forest and planting wheat fields, creating a pattern which would be interpreted as the Pythagoras theorem.

The Universe holds so many secrets and it still has very much to tell us. Eden Phillpotts (1862-1960) wrote a book[1.8] in 1918, '*A Shadow Passes*', in the form of Observations and Poems. On page 23 he notes:

"The universe is full of magical things
waiting for our wits to grow sharper."

Religion also can play a part in Astronomy literature. Perhaps the Reverend Edward Young (1683-1765) is the most famous in this connection. It has been claimed that he has brought out, better than any other poet, '*the religion of the stars*'. Between 1742 and 1745 he wrote '*Night Thoughts*' and, added to it, there is a poetical paraphrase on part of the Book of Job, and on the last day poem he writes:

"O let me gaze!—Of gazing there's no end."

Also, within '*Night Thoughts*', in Night IX, line 771 he says:

"An undevout astronomer is mad."

There are many who have no inkling of what the study of the heavens tells us. In an interview[1.9] with James Alfred van Allen, famous for his discovery of the radiation belts around the Earth, he describes this apathy saying that:

"In some sense, there's nothing as impractical as astronomy. You could take away the whole astronomical universe, and most people wouldn't know the difference—except for the Sun and maybe the Moon."

But there are many others who believe that everyone should be able to enjoy observing the night sky in all its glory. As early as 1935, the philosopher Bertrand Russell raised concerns on how the development of light pollution was affecting this privilege. He wrote[1.10]:

"Most of us have never seen a comet. I have seen two, but they were less impressive than I had expected them to be. The cause in our attitude is not merely rationalism, but artificial lighting. In the streets of a modern city the night sky is invisible; in rural districts, we move in cars with bright headlights. We have blotted out the heavens, and only a few scientists remain aware of stars and planets, meteorites and comets. The world of our daily life is more man-made than at any previous epoch. In this there is loss as well as gain: Man, in the security of his domain, is becoming trivial, arrogant, and a little mad."

Over the years, the International Astronomical Union (IAU) has established a '*Dark and Quiet Skies*' project to raise awareness for the need to preserve one of nature's precious gifts. Through the project, people can learn about the importance of dark skies for human culture, heritage and health, as well as the use of dark and quiet skies for astronomical research. Criteria have been proposed for any dark sky site to obtain official status. Much local lobbying is now undertaken to control the effects of street lighting and areas have been designated in the UK and elsewhere to provide official dark sky sites.

More recently, with contributions by members of the IAU and with the organisation's endorsement, a Report was published in 2024 by the International Union for the Conservation of Nature (IUCN). Entitled '*The world at night: preserving natural darkness for heritage conservation and night sky appreciation*', it can be obtained as a free download[1.11] from the internet. It is comprehensive in dealing with all the disturbances caused by light generated by human activity.

It describes various types of light pollution and their impacts across the globe, including effects on wildlife, as well as compromising research of professional astronomers and the enjoyment of the amateur brigade. It also summarises the lessons learned from certified dark sky sites. Chapter 8 entitled '*Closing Remarks*', quotes the twelfth quatrain of a poem, '*The Lighthouse* ', written by Henry Wadsworth Longfellow (1807-1882) in 1849. Although the four lines stand alone relative to the chief sentiments of the

whole work, they dramatically portray the effect that '*unnatural*' light can have on wildlife. Referring to '*The Lighthouse*' it reads:

"The sea-bird wheeling round it, with the din
Of wings and winds and solitary cries,
Blinded and maddened by the light within,
Dashes himself against the glare and dies."

A local dark sky is important to us all of us. James Thurber, the humorous essayist, made the comment in his book of 1961, '*Lanterns and Lances*':

"There are two kinds of light—the glow that illuminates,
and the glare that obscures."

Even simple measures can be taken to counter '*glare*' problems. Not only can better siting reduce contributions to sky brightness, it can improve what is required by local illumination. There is nothing worse than to approach a house with security lights producing a glare all around and directly into your face. A substantial amount of such glare light goes upwards to the sky.

Although not perfectly accurate, a nine-level numeric scale can be used to specify the brightness of the night sky at any location. Known as the '*Bortle Scale*', it ranges from Class 1 for the darkest sky possible to Class 9 for the busiest illuminated urban areas. In addition, the classifications are accompanied with figures for the limiting magnitudes of stars that might be seen by the unaided eye. The Bortle Scale is mainly used by amateur astronomers to assess what might be the best local area for undertaking their observations and for introducing people to gain familiarity of the constellations.

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With the advent of interplanetary space missions, there have been times when it was possible to look back towards the Earth with the challenge for us to appreciate just how small we are in relation to the vastness of space.

On the 19th of July 2013, the Cassini probe was behind Saturn with the Sun eclipsed by the giant planet (see Fig. 1-6). The opportunity was not missed for the mission's camera to capture images of the inner planets, including the Earth. At the time, our planet was at a distance from Cassini of just under 900 million miles.

To commemorate the occasion on the day, many parties were organised in a campaign referred to as '*The Day the Earth Smiled*'. Many Earth-dwellers turned to the Sun with Saturn behind it and had their pictures taken by Cassini. Their faces were recorded simply within the tiny point of bluish light. Closely adjacent was a fainter point of light, our own Moon.

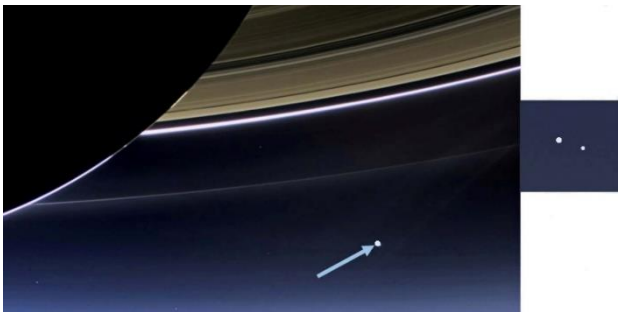

**Fig. 1-6:** Cassini's image of 19 July 2013 with Saturn eclipsing the Sun. A tiny dot against the black sky is the pinpoint image of the Earth, marked by an arrow. On the occasion, many groups of people gathered and waved to the Sun with Saturn behind it to have their photographs taken by Cassini. To the right, a small section around the Earth's position has been processed revealing the second small fainter point dot of our Moon.

Four days later, Messenger, which was orbiting Mercury at a distance of 61 million miles from us, remarkably provided a similar image of the Earth with our nearby Moon.

It is mind blowing from both space missions to realise just how small is the gap between the point images revealing the distance of the Moon in relation to the size of the Solar System. Without belittling the man-landing on our nearest neighbour in 1969, we can say that direct space exploration by human presence has been very much limited to our immediate doorstep.

A previous look back to the Earth was made by the Voyager 1 probe on the 14th of February 1990 as it was leaving the Solar System. Carl Sagan who, at the time, was in the limelight as an author and television programme presenter, referred to the image of the Earth as '*the pale blue dot*'. His famous quotation reads:

> "It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me it underscores our responsibility to deal more kindly with one another and to preserve and cherish the pale blue dot, the only home we've ever known."