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Mapping the light fantastic at Newgrange

Frank Prendergast
Technological University Dublin, frank.prendergast@tudublin.ie

Clare Tuffy
Office of Public Works, claretuffy@gmail.com

John Lalor
National Monuments Service, john.lalor@housing.gov.ie

See next page for additional authors

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Authors
Frank Prendergast, Clare Tuffy, John Lalor, Claire Breen, and Sinéad Gargan

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NEW LIGHT ON NEWGRANGE



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Frank Prendergast, Clare Tuffy, Sinéad Gargan, John Lalor and Claire Breen

Mapping the light fantastic at Newgrange

Shedding new light on the solar illumination in the burial chamber on winter solstice.



Above: Fig. 1—Direct sunlight in the burial chamber on 24 December 2020, 09:00:06 UTC: the moment of culmination (John Lalor).

Right: Fig. 2—The rising sun on 24 December 2020, 08:59 UTC, captured by a video camera mounted at a high level (Alisha Naughton and Des Swords).

THE WORLD HERITAGE PROPERTY of Brú na Bóinne attracts thousands of visitors from Ireland and around the globe, many drawn by the remarkable winter solstice phenomenon, when the rising sun's rays illuminate the burial chamber. During 2020 it became clear that public health measures to combat the global pandemic were going to preclude visitor access to the chamber of the Great Mound of Newgrange, including during the annual winter solstice celebrations. In normal years, hundreds would gather on the days around 21 December to witness the phenomenon at first hand and to celebrate it by gathering outside the monument.

In 2009 a Brú na Bóinne Research Framework was established for the World Heritage Property, which identified areas for further study and analysis. When the OPW and the NMS discussed how to manage Newgrange and the solstice during a time of great public health restrictions, Clare Tuffy, Manager of Visitor Services at Brú na Bóinne, suggested that the absence of visitors from the Newgrange chamber would present an opportunity to advance aspects of the Research Framework, specifically to explore, document and better understand aspects of the solar illumination during the solstice.

Guided by Dr Frank Prendergast, a multi-disciplinary team devised a research project to record direct sunlight on the floor of the Newgrange chamber over a period of 41 days around winter solstice 2020 and apply geographic information systems (GIS) software to investigate the direction and length of the sunbeam. A high-resolution digital archive would be created from the photographic data, along with a landscape model of the horizon surrounding Newgrange for users of Stellarium—a free open-source planetarium for computers. At the same time, plans were being made to webcast the solar illumination of the tomb over three days, 20, 21 and 22 December, to a global audience, which required close co-ordination and integration with the proposed research.

A summary of the first results of the research to date is reported below, along with some background information on the solar illumination at Newgrange passage tomb.

NEWGRANGE AND ARCHAEOASTRONOMY: A BRIEF HISTORY

In 1967 Prof. Michael J. O'Kelly became the first person in modern times to witness the solar illumination of Newgrange passage tomb on winter solstice. He famously recorded it as follows:

> 'At exactly 8.54 hours GMT the top edge of the ball of the sun appeared above the local horizon and at 8.58 hours, the first pencil of direct sunlight



> shone through the roof-box and along the passage to reach across the tomb chamber floor as far as the front edge of the basin stone in the end recess'.

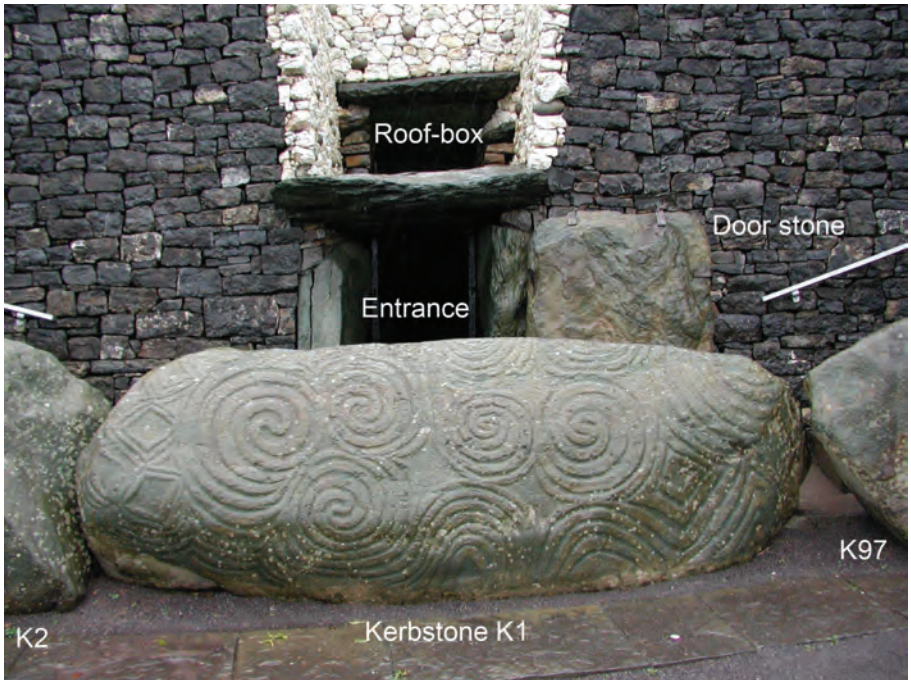
He describes the dramatic illumination of the tomb, how light reflected from the floor revealed so much of the archaeological structure, but by 9.15 the beam narrowed, receded and was 'cut off from the tomb'.

The phenomenon was scientifically investigated by Dr Jon Patrick, who published his findings in a short paper entitled 'Midwinter sunrise at Newgrange' in the journal *Nature* (1974). The astronomer Prof. Tom Ray was also keenly interested in the alignment of Newgrange; he re-measured the structure and his publication (1989) supported the theory that Newgrange was intentionally constructed to face the rising sun on the winter solstice.

Some additions to this story make for interesting reading. In 1909 Sir Joseph Norman Lockyer, an English astronomer, had published a reference to the solar alignment of Newgrange. Lockyer is not known to have ever visited the Boyne Valley but drew instead from a plan of the tomb published by the Irish archaeologist George Coffey in 1896. To Lockyer's astronomically trained eye, the south-eastward orientation of the entrance passage depicted on Coffey's plan allowed him to speculate that 'New Grange, … so far as I can make out, is oriented to the Winter Solstice'.

In 1978 Claire O'Kelly wrote about a belief or tradition prevalent in the locality of Newgrange that the rising sun, at some unspecified time, illuminated the beautifully carved three-spiral motif on the vertical face of stone C10 in the end recess of the cruciform-shaped chamber, but the hidden aspect of that stone and its motif prevents any direct illumination by the sun.



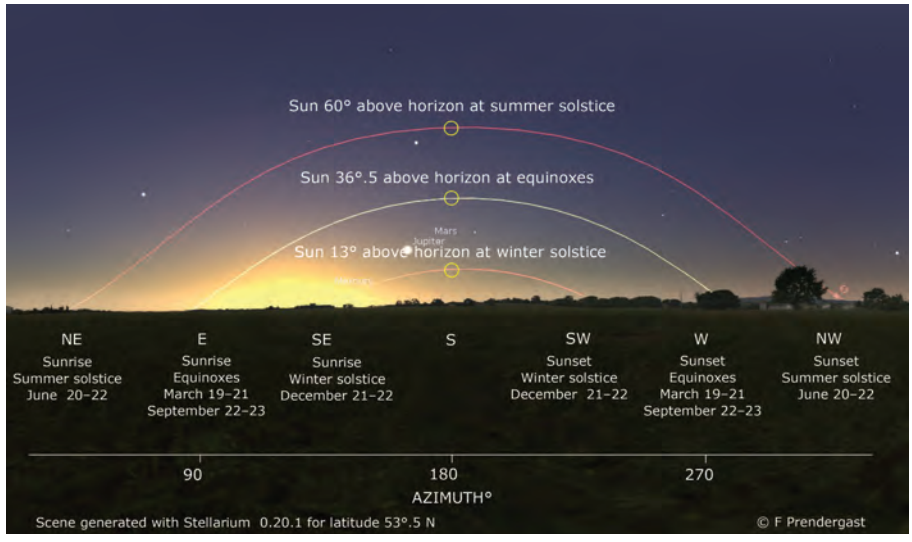


Above: Fig. 3—Newgrange passage tomb: entrance architecture and art (Frank Prendergast).

INTERDISCIPLINARY COLLABORATION AND INNOVATION

To record the light, a full-frame digital SLR camera was centrally positioned at a high level to look vertically down onto the floor of the burial chamber. A focal length of 16mm ensured the maximum field of view of the floor below. The camera was connected to an adjacent computer networked to an external router. This allowed the NMS photographer to remotely control and adjust exposure settings during real-time monitoring of the chamber floor and to capture photographs in the chamber; on average three per minute were taken each morning. To assist with the research and also with the global webcast, two video cameras were installed in weatherproof enclosures, one mounted in the roof-box and another at the entrance, looking up the passage. An additional two motorised dome cameras were positioned inside the tomb.

During the Neolithic, *c.* 3100 BC, access to the tomb was likely controlled by the massive door-stone now standing to one side of the entrance. Light would therefore only have entered the tomb via the roof-box. To replicate those same conditions, a timber door, aptly named the 'Boyne Door', was fabricated to exactly fit the profile of the passage.



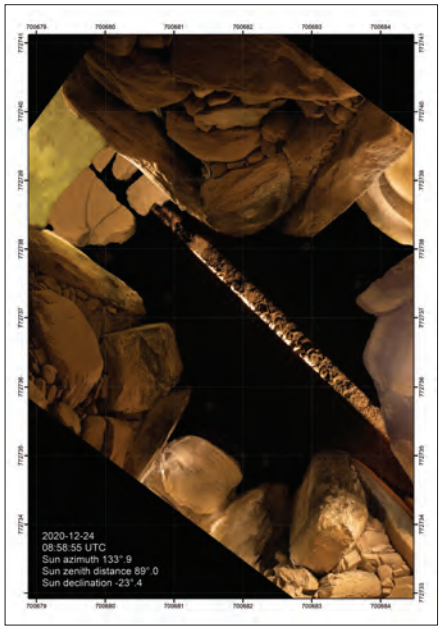
Below: Fig. 4—Apparent movement of the sun throughout the year, giving the seasons and the variable daylight length of *c.* 8.5 hours between the shortest and longest days (Frank Prendergast).

'SEEING THE LIGHT'—MAPPING THE LIGHT

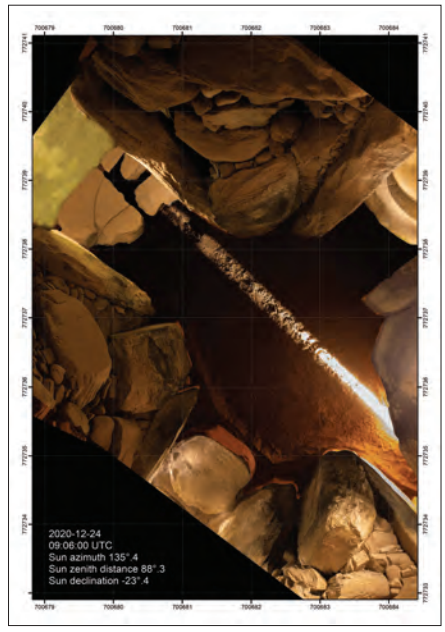
Even when the sun is well below the horizon there is ample light in the sky between civil dawn (where the sun is 6° below the true horizon) and local sunrise. Yet 'waiting for the light' at Newgrange is a truly unforgettable experience—that split second when the upper limb of the golden orb of the sun spectacularly bursts out of the crest of Red Mountain, 2.7km away to the south-east. Seamus Heaney's poem 'A Dream of Solstice' pictures the magic of it all:

> 'Of sunrise, for an eastern
> dazzle
> To send first light like
> share-shine in a furrow
> Steadily deeper, farther
> available,
> Creeping along the floor
> of the passage grave
> To backstone and
> capstone, to hold its
> candle
> Inside the cosmic hill.'

From 1 December 2020 the project moved into 'Lights! Camera! Action!' mode and began the synchronised recording of events in the chamber and on the distant horizon. The processing of the photographic images, a sample of which are shown here, required a scientific approach







never before attempted in this context. GIS software was used to create a suite of precision 'maps'. These show the archaeological structure of the cruciform tomb in relation to the dynamic beam of direct sunlight moving across the chamber floor in all its ephemeral beauty. It enabled the charting and measuring with centimetre accuracy of what Heaney terms 'the creeping first light'. This was made possible by using complex geo-processing tools in the GIS software environment to manipulate each photograph onto the National Grid. Tables of variables were computed to astronomically stamp each image according to the exact location, time and date.

DISCOVERIES SO FAR

With the doorway blocked, direct sunlight and the wider beam of ambient light could only enter the chamber via the roof-box (Fig. 1). This allowed the chamber to be illuminated as the original builders intended and provided an unprecedented glimpse into the past. Over the 41 days of capturing imagery, cloud cover allowed for a success rate of 53%. The imagery confirmed that direct sunlight in the chamber is evident for more days centred on the winter solstice than previously known but that it reaches its peak brightness on the days around 21 December. The last traces of direct sunlight entering the chamber were captured on 8 January 2021.

The first generalised results from the analysis of the photography show that:

- the chamber is in near-total darkness until a few minutes before sunrise;
- as the sun climbs out of the horizon, brightness in the chamber appears initially as a 26cm-wide beam of ambient light on the floor;
- the sunbeam ingresses onto the faint beam of ambient light, like a pencil point or sun dagger, and rapidly shoots along it as far as the end recess of the chamber, reaching a maximum width of 17cm (Fig. 5);

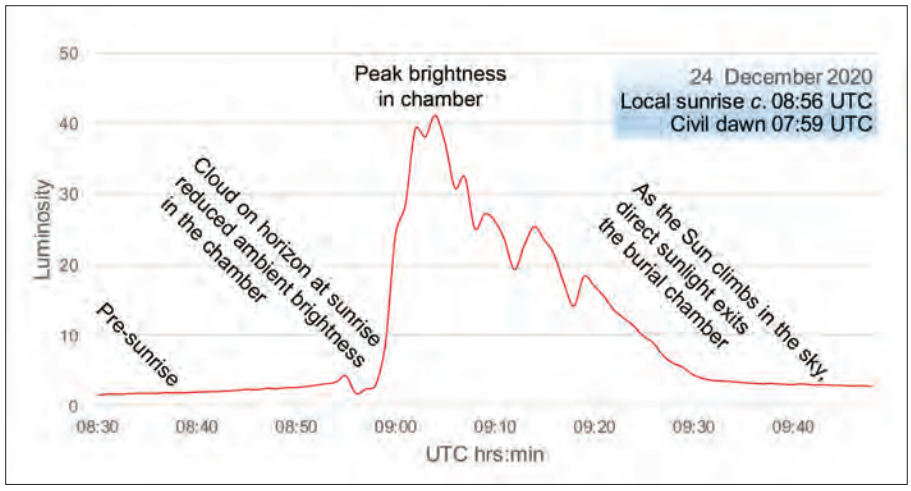
Above, from left: Fig. 5—Direct sunlight in the burial chamber on 24 December 2020 at 08:59 UTC, one minute after ingress. True north on the plan is 1° 2″ west of grid north (Frank Prendergast and John Lalor).

Fig. 6—The moment when direct sunlight culminates on 24 December 2020, *c.* 09:00 UTC. The sunbeam reaches the entrance to the end recess of the cruciform burial chamber. The sunbeam is then 3.49m in length and 17cm at its widest (measured by GIS). The ambient beam of light is 28cm in width (Frank Prendergast and John Lalor).

Fig. 7—Direct sunlight rapidly recedes from the moment of culmination, 24 December 2020, 09:06 UTC. The sunbeam will leave the burial chamber by *c.* 09:15 UTC (Frank Prendergast and John Lalor).

Table 1—Horizon co-ordinates for the sun as used in the illustrations.

Photograph no.	Sun azimuth°	Sun true ZD°	Sun declination°	Remarks
20201224-08-58-55	133.9	89.0	–23.4	One minute after ingress
20201224-09-00-06	134.2	88.9	–23.4	Moment of culmination
20201224-09-06-00	135.4	88.3	–23.4	Nine minutes before egress



- the brightness level in the chamber increases dramatically to its maximum in a matter of minutes (Fig. 6);
- the sunbeam quickly begins to recede towards the entrance to the chamber (Fig. 7);
- the decrease in brightness in the chamber is more gradual, tailing off to an ambient level a little brighter than pre-sunrise levels.

Further analysis will continue and, most significantly, the archaeological record for Newgrange has now been enriched by a new digital archive.

CLARE TUFFY REFLECTS ON WINTER SOLSTICE 2020



'The broadcasts were stunning, informative and inspiring. Watching the first rays of sun enter the tomb as they have for more than 5,000 years brought such hope after a year that has sometimes felt hopeless. The commentary was extraordinary, not only teaching us about the origins of the monument but also reminding us of the darkness and light felt by all humankind throughout the ages'—Rose Foley, Co Galway.

'If ever there was a time for the light to shine at Newgrange, winter solstice 2020 was it. The 5,000-year-old monument gave us hope and the reassurance of brighter days ahead when we needed it most.'

Above: Fig. 8—Luminosity in the burial chamber of Newgrange passage tomb on 24 December 2020, 08:30–09:45 UTC. The space is at its brightest *c.* 09:00–09:05 UTC (Frank Prendergast and John Lalor).

Opposite page:
Fig. 9—Facing the sun at Newgrange on 21 December 2013 (Ken Williams).

In times of crisis and uncertainty, we all need hope and reassurance that everything will soon be all right and life will return to normal. In ancient times, people no doubt turned to the Great Mound of Newgrange at such moments of crisis, worrying about crop failures, sick animals and children. To be able to pinpoint exactly when the year had turned must have seemed a great achievement, and indeed it was. Their leaders no doubt promised those gathered there for winter solstice dawn that they had things under control and that the ancestral deities they worshipped would intervene. If ever there was a time for the light to shine at Newgrange, winter solstice 2020 was it. The 5,000-year-old monument gave us hope and the reassurance of brighter days ahead when we needed it most. The live webcasts received more than two million views from across the globe over the three days.

The winter solstice event at Newgrange has changed a lot over the decades. From the 1960s there was a waiting list for applicants who wanted to be in the chamber at dawn. In 2000 this changed to a fairer and more democratic lottery system. The lottery generates a huge amount of excitement, with the winners often travelling halfway round the world on the off chance of seeing sun in Ireland in December! Over the past decade, the average number of lottery applications has remained steady at about 30,000 each year.

In 2007, 2008 and 2017 there was a live webcast of the solstice event and the general reaction from the public was positive, albeit low-key. When we decided to webcast the event again in 2020 we certainly didn't anticipate any different response. The first indication we got that this was going to be an exceptional year was when the Department of Foreign Affairs and Fáilte Ireland offered to share the webcast on all their social media platforms.



When we were planning our broadcast, we couldn't have known that the Covid-19 lockdowns in place in many parts of the world would so intensify the connection that people feel to the monument and its message of hope, renewal and regeneration. Friends and relatives abroad appeared to feel an even stronger connection to home and to their heritage in a year when home seemed so far away.

Winter solstice 2020 was different. For the first time ever, we were able to seal the doorway so that the light illuminating the chamber was only that which shone through the roof-box. We also had the opportunity to study the winter solstice phenomenon in more detail than ever before and collect imagery and measurements that will inform future research.

For one year only, the sound of nature at the monument was all we heard. As beautiful and moving as this was, the people were missed. It is likely that 5,000 years ago people from all over Ireland attended the solstice ceremonies and celebrations at Newgrange. It is a place to gather and celebrate today, just as it was then. It is our touchstone, an iconic national monument, and without people there the experience of winter solstice dawn is simply not the same.

The OPW received thousands of messages after the winter solstice webcast. Not one was negative. People poured out their feelings, describing the impact that the images of the light entering the dark chamber and the commentary had on them.

It is our hope that we can learn from winter solstice 2020 and find a new way to celebrate solstice in the years ahead, perhaps having lottery-winners inside on some days and webcasting from an empty chamber on others.

Solstice 2020 was a once-off, but what an extraordinary experience! In a time when we had to stay apart to be safe, it was one of the most inclusive events of the year. AI

Acknowledgements

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