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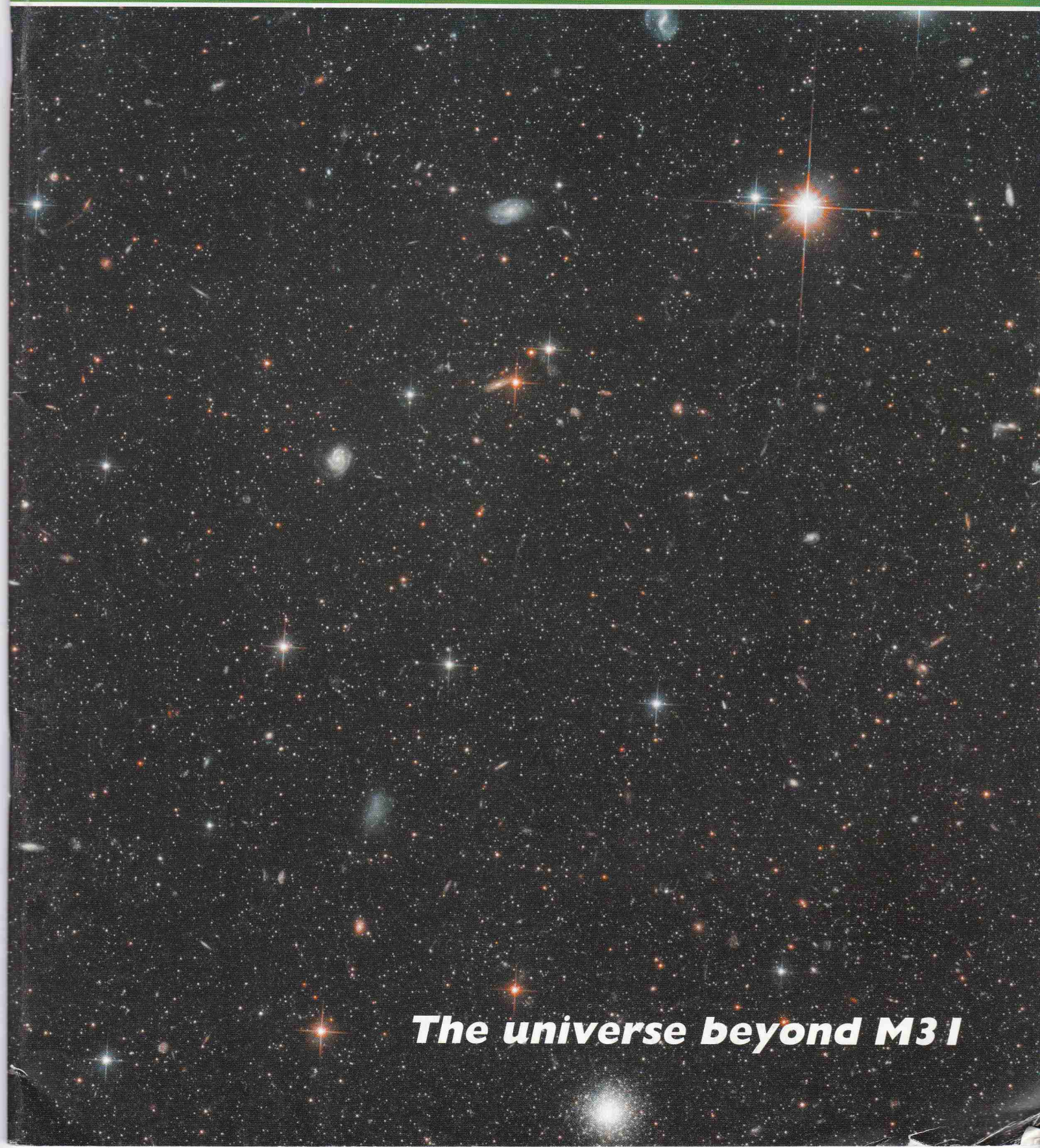


The universe beyond M31

A scale model of the solar system in an English village

Barry Keenan

Introduction

In 1999 Otford Parish Council in Kent called for suggestions to celebrate the forthcoming millennium. In July Mr David Thomas MA, a retired schoolteacher, proposed that the parish build an accurate scale model of the Solar System to show the positions of the planets as they were at midnight on 2000 January 1. The model should fit within the parish boundary and be accessible to the public. It was intended that the model should last a thousand years: when the next millennium arrives, astronomers should be able to calculate when it was erected to within about 15 minutes, assuming it survives.

This proposal was discussed at a Parish Council meeting. During this discussion I, as a parish councillor, commented on the proposal, pointing out certain irregularities in the positions of the planets, explaining that I was also an amateur astronomer. The Parish Council had never received a proposal of this nature and were intrigued as to its viability, but approved the idea providing the cost of construction was found elsewhere.

I was given the job of overseeing the project on their behalf. I stated that if the project was to be carried out, it should be as accurate as possible or it would have little value in the astronomical world. We checked on the Internet to see if a solar system model had been built anywhere in the world, but could not find anything similar to David's proposal. We found three other solar system projects. One is in England between York and Selby, set up by three staff members of the University of York on the Sustrans cycle path [http://www.solar.york.ac.uk/index.html]. It is seven miles from the Sun to Pluto. A Millennium Award from the Royal Society funded this project.

The other two are in America. One is at Eugene in Oregon [http://www.efn.org/~jack_v/]. The scale is 1:1 billion with Pluto at 3.66 miles from the Sun. The other is the Carl Sagan Planet Walk at Ithaca Commons, NY, with a scale of 1:5 billion [http://www.sciencenter.org/saganpw/]. All are 'Line of sight models'. Ours would be the only one which is both fully scaled and time sensitive.

Calculations

On meeting with David Thomas and looking at the information he had produced it was clear the data needed amending. I initially contacted Mr Gordon Taylor (Director of the Computing Section, British Astronomical Association), who confirmed my initial data and understanding of how one calculates the positions of the planets. David calculated the reduction in scale so Pluto would just fit within the parish boundary. He arrived at a scale of 1:4.6 billion with the Sun reduced in size to 303mm diameter. I then carried out some initial calculations of the distance of the planets from the Sun using trigonometry and geometry. These calculations were rough and ready so I went on the Net and collected data from the US Naval Observatory, Washington DC (USNO). The data obtained was excellent, and was used by David Thomas and myself to refine the positions and reduction in size of the Solar System, so as to fit within the parish boundary.

Siting

Initially David suggested placing the solar pillar on the village green opposite the village pond (a listed building). It was soon apparent some of the planets could not be sited in their correct positions or would not be accessible to the public. We looked at other possible locations and eventually opted for the village sports field as the best possible site; only two outer planets would be slightly out of position, but all would be publicly accessible. Mars posed a problem as it lay between two football pitches. The recreation committee felt that a concrete pillar close to the edge of the playing area would be a hazard (we imagined the press reporting: 'Football player injured on Mars!') We compromised by agreeing to set a short pillar flush with the ground. During the annual village fete or other special occasions we set up a temporary pillar in the Mars position.

Most of the planets would be sited on parish owned ground or on the edge of public footpaths, with the exception of Saturn and Pluto. The Sun, Mercury, Venus, Earth, Mars and Jupiter would be positioned on the Parish Council's recreation area. Uranus and Neptune were sited on the edge of village roads (with Sevenoaks District Council's permission). The local doctor's practice agreed to Saturn being placed in their car park, and were delighted to have it there. We approached a local farmer, Mr Chard of Sepham Farm, requesting his approval to site Pluto on the edge of a public footpath running through his land, which he agreed.

Saturn, Uranus and Pluto would be sited slightly away from their calculated position in order to be accessible, but still at the correct distance from the Sun.

David Thomas *(left)*, Barry Keenan and Henry Hatfield with the solar pillar at the opening ceremony.

Materials

For economy and robustness we decided to use concrete pillars to mark the positions of the Sun and planets. However it was clear that concrete would not allow fine detail to show, so it was decided to engrave the planet to the correct relative size on a stainless steel disc which would be set into a recess on the top of the pillar.

Concrete

The concrete federation was contacted by phone and was asked if they could specify a mix of concrete that would be suitable to last a thousand years. After a long period of silence we were asked to repeat our query. We eventually wrote to them with our request and after a long delay received a reply to the effect that concrete had not been tested to last that long but gave a recommended mix with a type of white sulphate resisting cement, and to use stainless steel reinforcing bars. (It seemed they knew nothing of roman concrete).

Stainless steel discs

We next approached the steel federation asking for information on a type of stainless steel that would last a thousand years. They were more positive. Normal stainless steel would not last so long – it would rust! They eventually suggested we use a high grade steel that had a high content of chrome alloy.

We considered using bronze to represent the Sun, but this would mean high cost and probable corrosion. Then David found a company that could spin a flat sheet of stainless steel into a half sphere. This was just what we wanted. A steel ring would then be placed around the sphere, engraved with details and directions of the planets. The ring would also be engraved with the following: 'Scale model of the solar system showing the positions of the Planets as they were at 0hrs January 1st 2000'. Each planet would be represented by a scale engraving with its name and an arrow pointing in the direction of the Sun onto a stainless steel

David Thomas and Gordon Taylor at the solar pillar on the Otford recreation ground.

Above: Barry Keenan at Pluto, 0.98 km from the 'Sun'. *Below:* Cmdr Henry Hatfield opening the project on 2001 July 14.

Otford solar system model: reduced positions and distances

	Actual					*Reduced*			
	Diameter		*Distance from Sun*			*Diameter*	*Distance*	*Hel.*	*Location*
	Miles	*Km*	*AU*	*Miles*	*Km*	*mm*	*metres*	*long.*	
SUN	865,000	1,392,500				303			Playing field
Mercury	2900	4878	0.466	43,319,414	69,712,607	1.06	15.17	252.47	Playing field
Venus	7700	12104	0.720	66,931,284	107,710,466	2.63	23.44	181.79	Playing field by hedge
Earth	7925	12756	0.983	91,379,794	147,054,706	2.78	32.00	99.86	Playing field
Moon	2150	3476	*(from Earth)*	252,179	400,933	0.76	0.87		
Mars	4200	6794	1.391	129,307,522	208,090,637	1.48	45.28	359.13	Playing field between football pitches
Jupiter	88,700	142,800	4.965	461,546,978	742,753,425	30.91	161.62	36.24	Playing field by hedge
Saturn	75,100	120,000	9.184	853,745,709	1,373,906,838	26.11	298.95	45.70	Surgery grounds
Uranus	29,300	52000	19.924	1,852,137,359	2,980,587,962	11.31	648.56	316.41	Footpath to Broughton Road
Neptune	31,200	48,400	30.12	2,799,958,706	4,505,887,844	10.53	980.46	303.92	Telston Lane, back of wide pavement
Pluto	1528	2445	30.224	2,809,626,558	4,521,446,023	0.53	983.84	250.54	Footpath 15 by Twitton Brook, Sepham Farm

(Hel.long. = heliocentric longitude from the first point of Aries, degrees)

disc 303mm diameter (the Sun's scaled diameter). This would then be set into a shallow recess on the top of a tapered concrete pillar.

We decided Saturn should show its ring system with the angle as at 0hrs on 2000 January 1. The discs for the Earth and Jupiter were large enough to show the Moon, Io and Europa to scale.

We originally specified welding three lugs to the underside of the discs for setting into the concrete pillars but revised this idea, as we were advised welding could distort the discs. So we had to find an alternative method of securing the discs to concrete. An adhesive called Gripfil was available in builders' merchants so I approached the manufacturers who were intrigued as to its proposed use. They felt it could do the job. I tried it out on my garage floor by gluing a square of stainless steel to the concrete floor. 24hrs later I was unable to remove it with a hammer and chisel except by removing concrete as well.

Other considerations

Each pillar, weighing 0.5 tonnes, would be set upon a 600×600mm concrete paving slab laid on concrete 400mm below ground level, surrounded in concrete and pre-cast concrete segments laid around the pillar at ground level. The solar pillar would be a 1.3m 450mm diameter straight column with a recess on top to receive the solar sphere and ring. A set of year 2000 coins would be buried beneath the concreted slab in a sealed container. The solar dome would be filled with concrete to prevent its being dented by vandals.

The planetary pillars would be 1.3m high × 450mm diameter and tapered with a recess on top to receive the stainless steel disc.

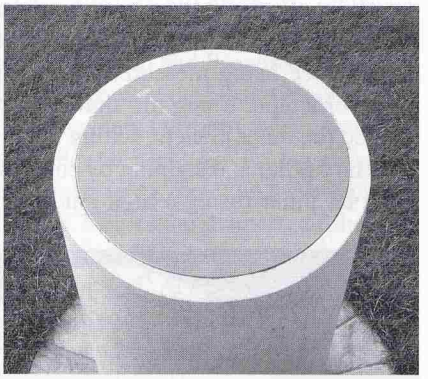
Cost and funding

We prepared specifications for the manufacture of the concrete pillars, supply of the stainless steel discs, ring and dome, and engraving the steel, including the ground works necessary for their erection. On receipt of the quotations we found we needed approximately £4400 to complete the project.

We approached the National Lottery for funding but were told that 'scientific projects did not meet their criteria'. The Millennium Awards For All Fund was of the same mind.

Whilst reading the annual report in the Royal Astronomical Society I came across the report of the Particle Physics and Astronomy Research Council (PPARC), which described grants for various research projects. The report mentioned the Council's small awards scheme for projects in public understanding of science and technology. David and I felt the project met these criteria and so I prepared an application for funding, not holding out much hope for success.

A few weeks later the Parish Council received a letter from PPARC granting us £4000 towards the project. I was led to believe the Parish Council's application was the only one to have been made to PPARC from a local authority.



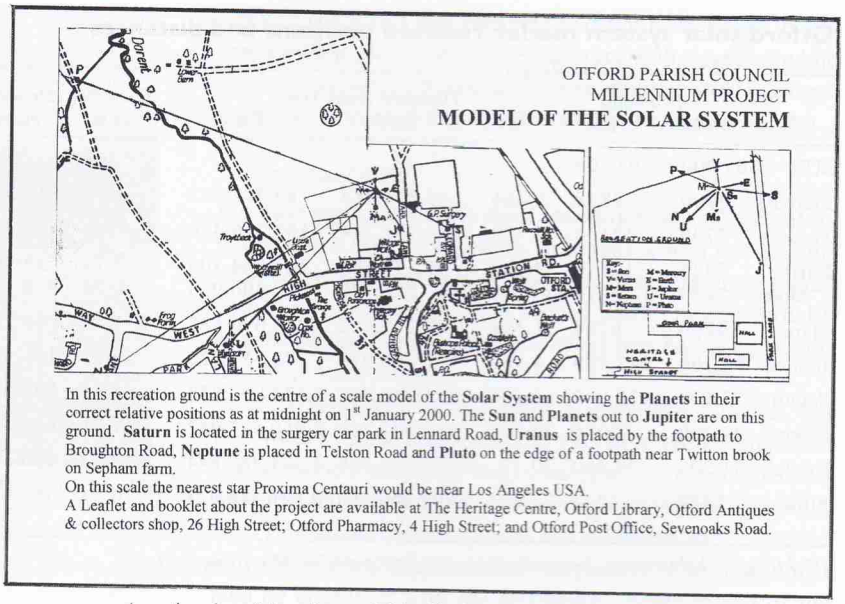
The top of a typical planetary pillar: this is the Earth and Moon.

We also approached Kent County Council Rural Revival Committee (KCCRV) for funding the printing of leaflets and a display at the local historical museum. After the project was completed KCCRV made a grant of £2500. The result of the PPARC grant was reported to the Parish Council who agreed to underwrite any further costs over £4000.

On this approval we awarded contracts to:

Seal Engineering: *For the supply of the SS discs and ring;*
Able Engineering: *To engrave the discs and ring;*
James & Spackman: *To supply the solar sphere;*
MHD Horticultural Contractors: *To erect the pillars.*

Otford Builders Merchants kindly offered to donate the paving slabs, ballast and cement for the placing of the pillars, and we purchased the pre-cast concrete segments from a local garden centre. A local printer printed leaflets.



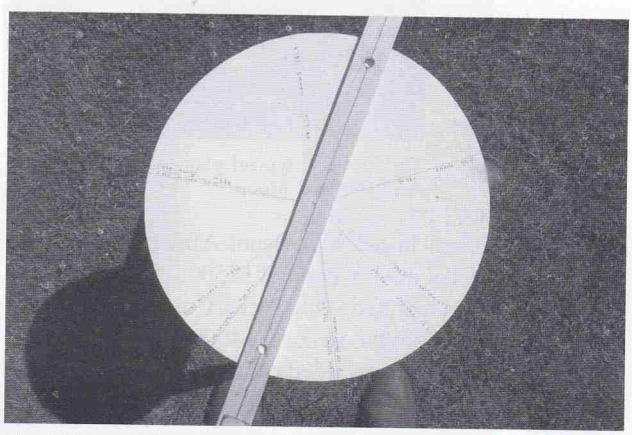
A notice describing the model is displayed in the village car park.

Setting up the pillars

The first requirement was to find the position of the Sun at noon for Otford and mark out a line. We carried this out by using a long pole set upright where the Solar pillar was to be sited and over a few days marked the shadow line for the Sun at noon (not forgetting of course the equation of time). This line was crucial in setting the planets' positions. We also needed a correct angle to align the arrows on the steel planetary discs and to align the pillars from the Sun.

Mercury, Venus, Earth, Mars and Jupiter could be set up by 'line of sight' as they were all on the recreation ground. We used large-scale Ordnance Survey maps to obtain the positions of the pillars from Saturn to Pluto. We started marking out the positions of the pillars on 2001 June 27 and erected the pillars on 2001 July 2.

The actual position of the solar pillar was guided by the position of Mars which lay between two football pitches, and Venus which would be close to a hedge at the back of the recreation ground. A large disc was made out of plywood with the planets' position angles and the first point of Aries marked from the centre, and a 700mm length of wood pivoted at the centre with sights on each end. For the planets on the recreation ground we could lay the disc on top of the solar pillar and set out the planetary angles, the distance being measured on the ground with a steel surveyor's tape. Using the sighting device in reverse we aligned the outer planets; setting the disc up on top of the planetary pillar and sighting by compass the angle back to the solar pillar (using a high grade surveyor's compass), first setting the angle of the noon Sun to the compass. This gave us the angle between the Sun, planet and first point of Aries.



The 300mm planetary alignment disc, lain on the solar pillar to align the planets Mercury to Jupiter, and used in reverse for the outer planets with the help of a compass.

Mr Brian Thomas, the groundwork contractor, dug each hole, set in the 600×600mm paving slab level on concrete then placed the pillar on top (each pillar weighed half a tonne). The hole was then filled with concrete to ground level and concrete segments set around the pillar. A problem arose when we were ready to set in the Pluto pillar. Foot and mouth disease prevented us from going onto farmland, so we had to abandon the attempt to erect the Pluto pillar until the restrictions were lifted, and the field's crop harvested. This occurred on 2001 August 16, long after the official opening.

Having got the pillars in place the next task was to set in the stainless steel discs including the solar dome and ring. Using the measuring disc previously mentioned we aligned each disc and fixed it in the recess on the pillar with the 'Gripfil'. The concrete was painted with an anti-graffiti liquid to prevent aerosol paint adhering to the concrete.

Official opening

When the project got underway we discussed how we should inaugurate it. David approached Sir Patrick Moore who was delighted at the prospect but felt too unwell to commit to attending an opening ceremony. He suggested a prominent local astronomer, Commander Henry Hatfield RN Ret, a long serving member and past President of the BAA and himself a solar observer.

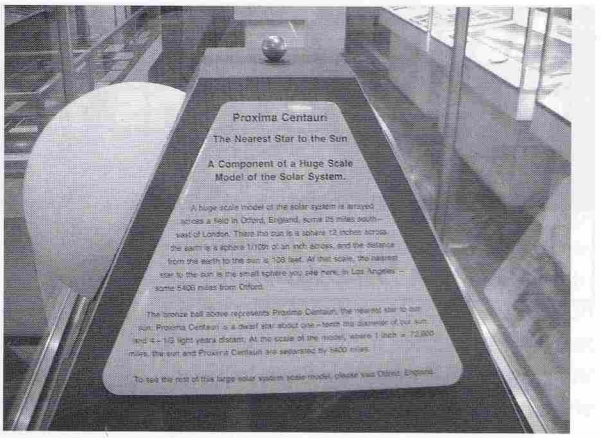
I wrote to Commander Hatfield asking if he would officially open the project, which he agreed to do. (Cmdr Hatfield was familiar with the project as he was a referee for the application to PPARC). The local and national press would also be invited. We were fortunate in having a resident who worked freelance for the *Daily Telegraph*.

As the official opening day approached we set about preparing an official guest list. The chairman of the Parish Council, Mr John Allen, made some suggestions and kindly agreed to introduce Cmdr Hatfield. Invitations were sent to PPARC, Mr Gordon Taylor, the local MP and the secretary of the Crayford Manor House Astronomical Society. The event was advertised in the local press and Parish newsletter.

It was decided to launch balloons from each planet's position and a sounding rocket from the outer planets so that visitors could see where the outer planets were situated in relation to the recreation ground. The village Scout and Guide groups kindly agreed to carry out this task.

A large meteorological balloon was obtained to represent the Sun. This had tassels attached to it representing solar flares, and was set in place above the solar pillar. 2001 July 14 duly arrived and at 14.00 hrs the project was officially opened. As Henry Hatfield neared the end of his speech the heavens opened up, drenching the 200 spectators and guests, however we managed to get the balloons and rockets launched. After the opening ceremony we retired to the Parish Council's heritage centre for refreshments.

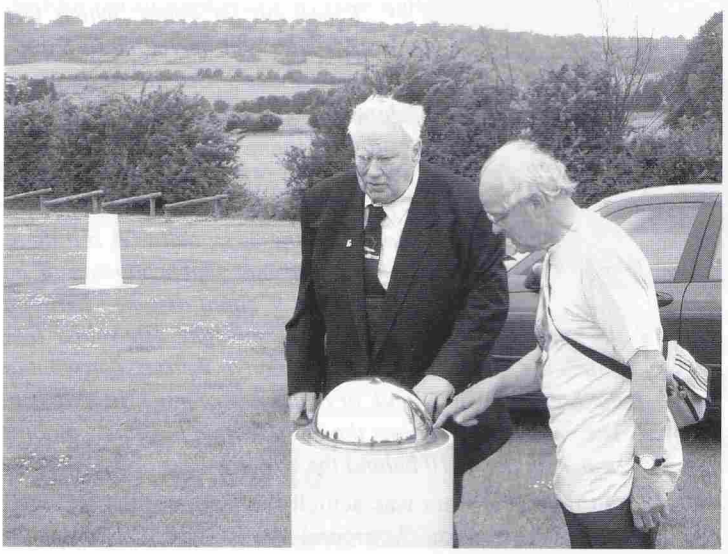
Later we launched the solar balloon with a message attached. Three days later it was found on the Grange Farm Estate, Kesgrave, Ipswich, Suffolk.



A scale model of Proxima Centauri located at the Griffith Observatory, Los Angeles.

There is a small exhibition on Astronomy at the Parish Council's Heritage centre, including details of the project. Leaflets can also be obtained about the project from some village shops.

Sir Patrick Moore paid us a visit on the afternoon of 2003 June 18, prior to giving a talk in Sevenoaks that evening. We gave him a tour of the solar system. He was most impressed with the project, especially its accuracy.



Sir Patrick Moore at the solar pillar on 2003 June 18. The Mercury pillar can be seen in the background.

Publicity

The *Daily Telegraph* ran an article on the project and later also the *Sunday Telegraph*. We also had coverage in the local newspapers. Later a diplomatic correspondent, Oystein Heggan from the Norwegian Broadcasting Corporation, interviewed David and myself. The BBC televised the event, which went out on regional TV, and later recorded the event more fully.

Further developments

David and I considered extending the model to include the nearest star to our Sun, Proxima Centauri, 4.22 light years distant. The scale of the Solar System indicated that Proxima Centauri would lie approximately near Los Angeles, 8681.37 km away. We contacted John Mosley of the Griffith Observatory, and he has erected a model of the Sun and Proxima Centauri to scale in the Visitor Centre at the Observatory.

A further enhancement currently under way is to set up a pillar for the star Alpha Canis Major (Sirius), which is 8.7 light years away, and from the latest information available, 2.2 times the diameter of the Sun. Sirius is the furthest well-known star to fit on the face of the Earth within the scale of the model. It would lie approximately near Sydney, Australia. The Falkland Islands is also being approached regarding the possibility of exhibiting a model of Barnard's Star.

We are seeking the title 'Largest scale model in the world' with the *Guinness Book of Records*.

The model has been awarded the prestigious Rouse Kent Art award for the most interesting piece of outdoor art in Kent for 2002. There was much discussion amongst the judges as to whether the model was art or science. They decided unanimously that it did not matter!

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