Australian Astronomy

ASA Factsheet No. 7 **The Alignment of the Planets**

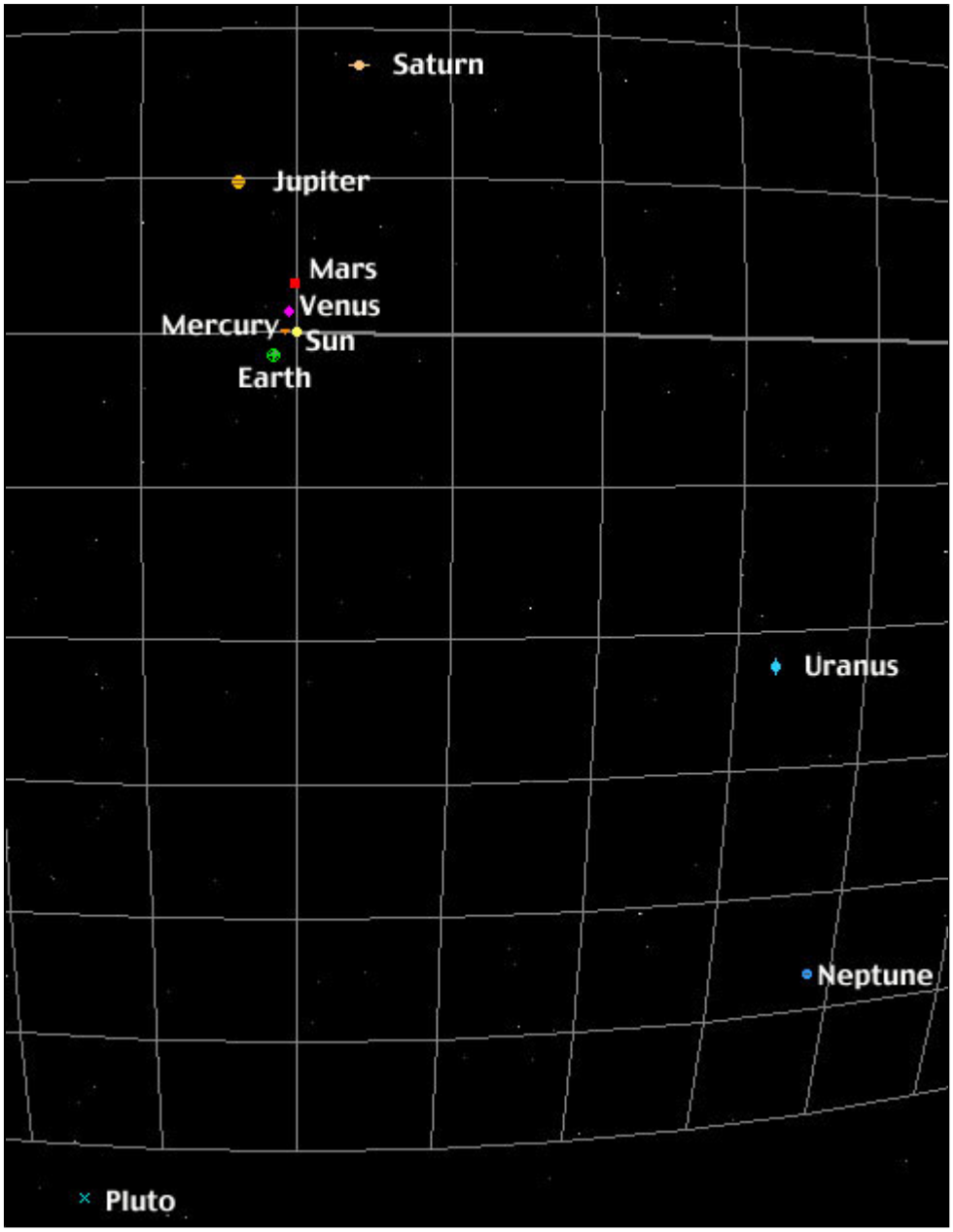
UPDATE Another alignment was scheduled for April-May 2002. See the diagrams below.

Many people will have heard about alignments of the planets. As seems to be usual with such things (yes, they do happen quite often), there are some who make dire predictions about the consequences of such a cosmic display. Is there any basis to these predictions of doom? Well,...no. Is there a spectacle to see in the sky? Not really, because the brightness of the Sun will interfere, however you can watch the planets congregating in the weeks before and then dispersing afterward.

We will summarize a few of the facts below and provide some links to allow you to explore these questions further on the web if you wish.

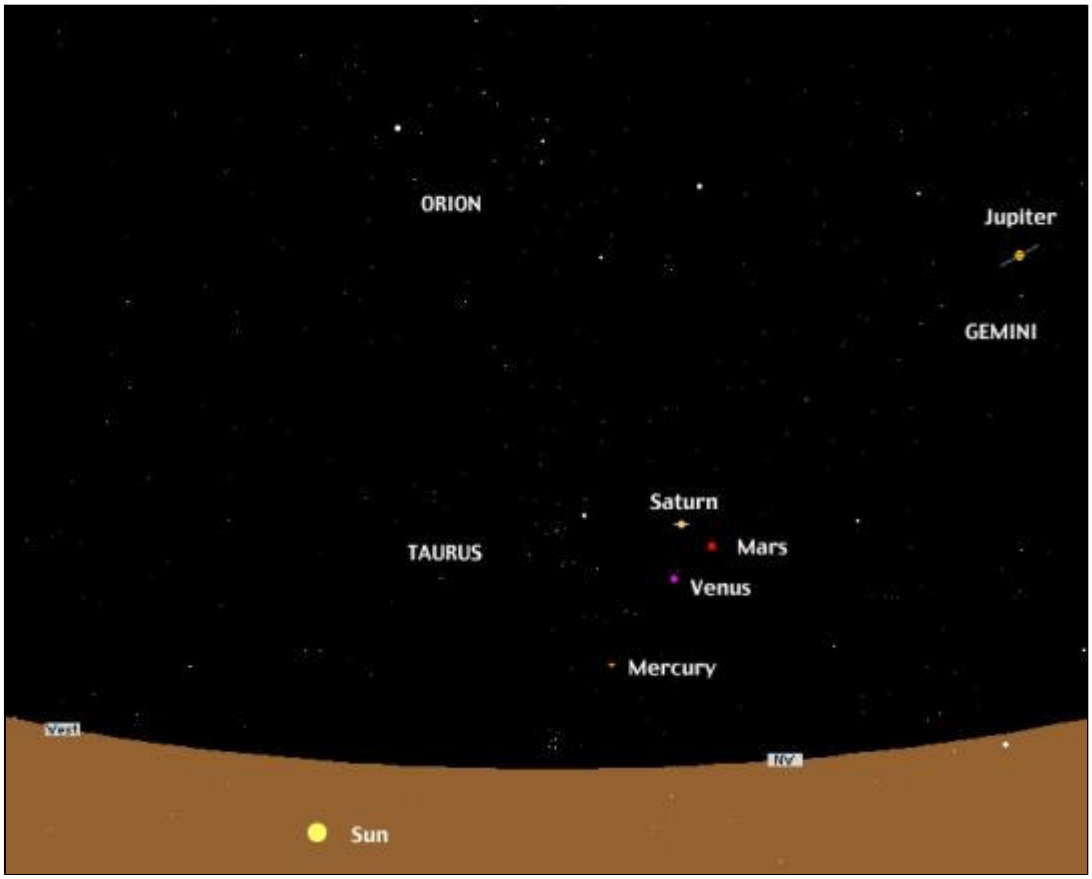
(For our Australian readers it is perhaps worth noting that James Cook's exploration of the east coast of Australia was due, in part, to a planetary alignment of sorts. A very good alignment of the Sun, Venus and Earth produced the transit of Venus across the face of the Sun that Cook observed in Tahiti before travelling westward to Australia.)

The May 2002 Alignment



The planetary 'alignment' on 5 May 2002 - as seen from above the north pole of the Sun.

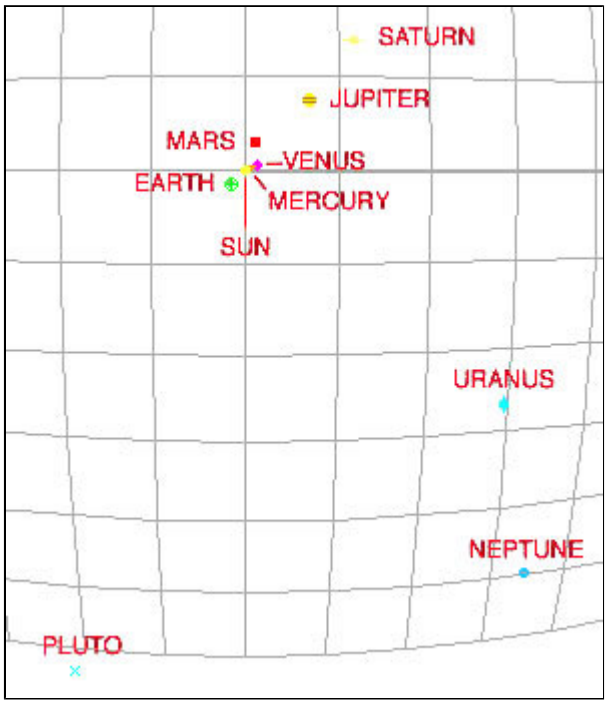
The minimum separation of the planets in our sky occured at around 5 May. This is best explained by the illustrations. The first shows the positions of the planets as seen from a point far above the Sun. The slightly ragged line formed by the planets out to Saturn is quite apparent - as is the lack of participation by Uranus, Neptune and Pluto!



The second illustration shows the view in the sky from Earth - in fact from Sydney at 5:30pm on 5 May, when the planets were still above the north-west horizon. Don't be fooled by the black sky in the diagram. This illustration reveals the problem for potential observers - all the planets are near the sun in the sky and will be difficult to see!

The May 2000 Alignment

Why were the positions of the planets special on 5 May, 2000? It is easy to decide this question yourself using one of the 'planetarium' programs readily available to display the stars and planets as seen from anywhere on Earth (or even elsewhere in the Solar System). The illustrations used here were generated using Voyager II (on a Mac).

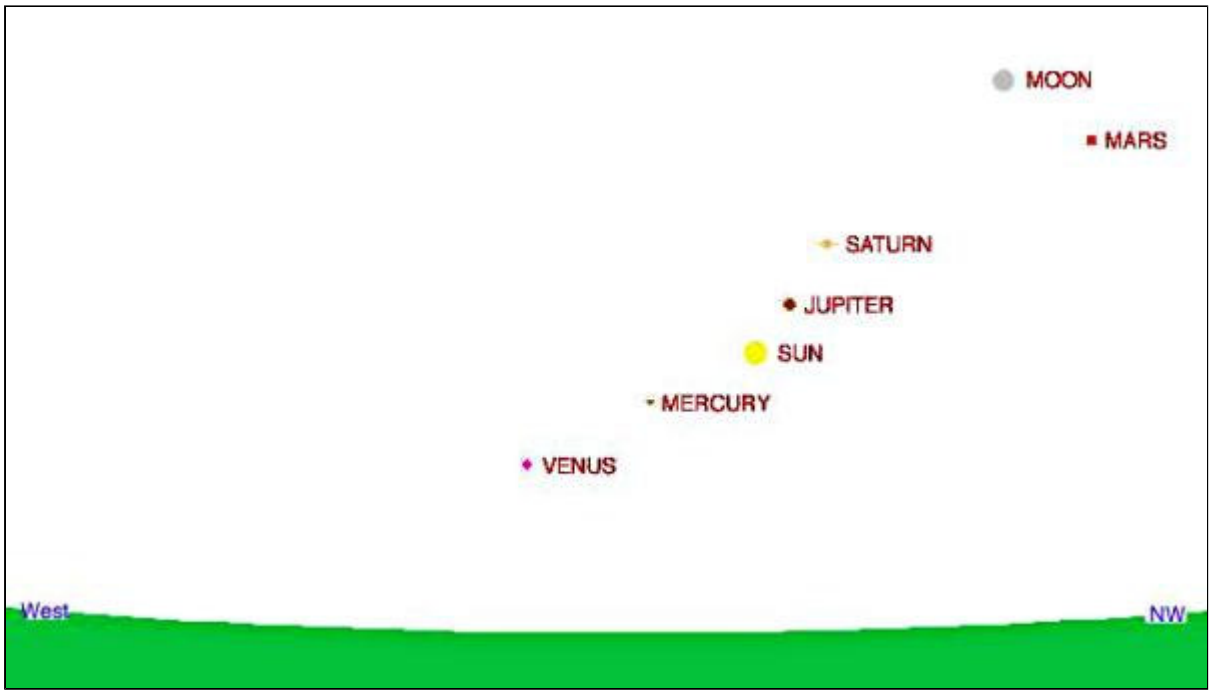


The minimum separation of the planets in our sky occured at around 6pm (Eastern Australian Standard Time) on 5 May. This is best explained by the illustrations. The first shows the positions of the planets as seen from a point far above the Sun. The slightly ragged line formed by the planets out to Saturn is quite apparent - as is the lack of participation by Uranus, Neptune and Pluto! Notice also that the Earth is in the opposite side of the Sun from the line of planets.

The planetary 'alignment' on 5 May 2000 - as seen from above the north pole of the Sun.
(black sky version of this image)

The second illustration shows the view in the sky from Earth - in fact from Sydney just 2 hours before the minimum separation, but when the planets were still above the north-west horizon. Don't be fooled by the black sky in the diagram. This illustration reveals the

problem for potential observers - all the planets are near the sun in the sky and will be almost impossible to see!



(black sky version of this image)

Of course the planets don't move too quickly, so this alignment persisted for a few weeks on either side of 5 May, forming a continually changing pattern. Only the fast-moving Moon will escape the congestion within a couple of days.

The minimum separation on 5 May was just under 26 degrees - spanning the distance from Venus on one side of the Sun, to Mars and the Moon on the other. Think about cutting a cake. If you cut a cake into 14 equal sectors, each sector will be just under 26 degrees across. On the sky, you could span from the Sun to Venus on one side, or the Sun to Mars on the other, by spreading the fingers on your outstretched hand.

If you excluded the Sun and Moon and considered only the five bright planets, then the 'magic' time and date changed to around 8:30pm (Eastern Australian Standard Time) on 17 May when the separation was only just over 19 degrees. At that time Jupiter and Venus were *very* close in the sky (only 1/100th of a degree) - but again invisible in the glare of the Sun.

Other Planetary Alignments

It is pretty easy these days to predict just where the planets will be in a few years time or in the past. Planetarium programs are readily available and there are sites on the web where you can plug in a date and see the positions of planets in the solar system displayed.

It turns out that alignments of various sorts are fairly common. Groupings of the brighter planets tend to happen at roughly 20 year intervals. This is because slow moving Saturn takes almost 30 years to complete its orbit, compared to 12 years for Jupiter. When Jupiter completes its orbit, Saturn has moved on in the sky and by the time that Jupiter has caught up with Saturn again, 20 years have passed. Then its just a matter of how well the faster moving inner planets can line up with these two.

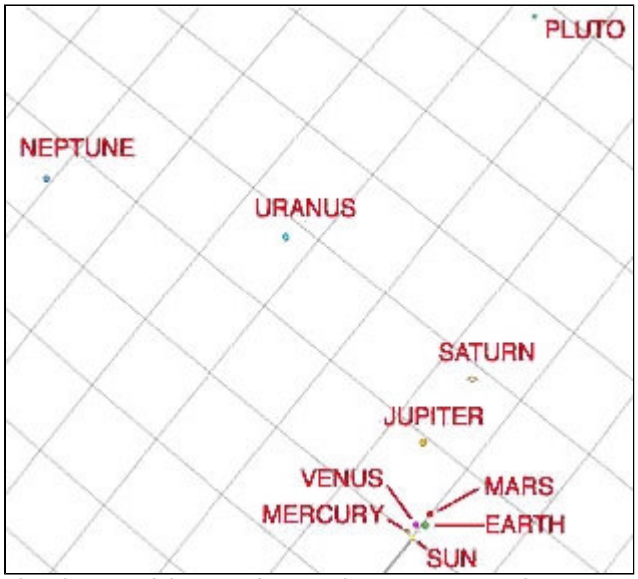
Nevertheless, the 2000 grouping, which includes the Sun and Moon, was quite a close one. Jean Meeus identified 40 occurrences of groupings like that in May 2000 - of the five naked eye planets plus the Sun and Moon (within 30 degrees ecliptic longitude) - between AD 1 and 3000. There was a tighter grouping (16 degrees) in 1962 and there will be a slightly wider one (29 degrees) in 2040. The alignment in September 2040 is better than this suggests because the five bright planets will come within only 10 degrees of each other, just to the east of the Sun. Unlike the 2000 alignment which was not be readily visible, in 2040 the planets will be visible low in the western sky at sunset, well placed for southern

hemisphere observers.

The Effects of Planetary Alignments

Interest in planetary alignments as a threat, rather than just a celestial display, was heightened and perhaps given some credibility about 25 years ago with the publication of *The Jupiter Effect: The Planets as Triggers of Devastating Earthquakes* by John R. Gribbin and Stephen H. Plagemann. That book predicted severe earthquakes in early 1982 caused by the combined gravitational effects of the planets in line. The dire predictions did not come to pass, but soon after the 'Grand Alignment' it was claimed that the real danger would instead come late in 1982, when the Earth was on the other side of the Sun from the other planets. There were warnings of an effect on the weather, perhaps even a Little Ice Age. None of this happened and John Gribbin has gone on to write some well regarded books on science for the public.

The 1982 so-called 'Grand Alignment' was just one example of a supposedly 'significant' alignment of the planets. In fact the line wasn't very good, but all nine planets were on the same side of the Sun, scattered over about 95 degrees in angle (see the diagram at right). Think about the cake again. 95 degrees is just over a quarter of the cake. That isn't such a 'grand' alignment (although this grouping did allow the Voyager 2 spacecraft to conduct a 'grand tour' of the outer planets in a relatively short time using the 'gravitational slingshot' effect as it passed each planet.) The 2000 alignment was much more impressive than that of 1982, but there will again be no significant influence on the Earth.



The planetary 'alignment' in March 1982 - as seen from above the north pole of the Sun.
(black sky version of this image)

Forces on the Earth

How might an alignment affect the Earth. The only plausible physical link is via the gravitational forces caused by the planets, which are easy to calculate. Newton's law of gravity tells us that each piece of the earth feels a gravitational force in proportion to the mass of the planet and inversely proportional to the square of its distance (i.e. three times the distance means only 1/9 of the force).

You can see Truman Collins' page for a detailed study of the 2000 alignment. Instead, lets make the calculation easy and assume that all the planets form a perfect line on one side of the Sun. What are the *relative* sizes of the gravitational effect on the Earth? The first column of numbers in Table 1 shows you (we'll set Jupiter's contribution at 1 since the effect is named after that planet!).

As you can see, the Sun has the greatest gravitational pull on the Earth. The Moon is a lot closer, but follows a long way behind in force because it is so small. The Moon and the Sun are always roughly the same distances from the Earth, so their gravitational effects don't change too much. Next in line are Jupiter and Venus, about 100 times weaker than the Moon, although these are about the maxiumum values for them. So, if all the planets lined up perfectly, they still wouldn't contribute much compared to the Sun and Moon.

Table 1 : Forces on the Earth due to the Sun, Moon and Planets		
Body	**Relative Gravitational Force**	**Relative Tidal Force**

Sun	19,000	78,000
Moon	96	150,000
Mercury	0.008	0.056
Venus	0.60	9.0
Earth	-	-
Mars	0.022	0.17
Jupiter	1	1
Saturn	0.072	0.035
Uranus	0.0025	0.00057
Neptune	0.0011	0.00016
Pluto	0.00000009	0.00000001
Assuming all planets at their average distance from the Sun and in a line		

This is interesting but not very relevant. If we're worried about stretching the Earth around a bit and causing earthquakes, then its the **tidal force** on the Earth we should worry about. This is the *difference* in the gravitational force due to a planet between one side of the Earth and the other. The Moon, for example, pulls more strongly on the side of the Earth closest to it than it does on the other side (remember that the gravitational force is inversely proportional to distance) and causes tides in the oceans and the land. The same is true for the pull of Pluto on the Earth, but Pluto is so far away that the difference between one side of the Earth and the other is pretty slight.

Like the basic gravitational force, this difference in force is proportional to the mass of the planet. But it is inversely proportional to the *cube* of its distance rather than simply its square (i.e. three times the distance means only 1/27 of the tidal force). So being close is very important.

If we again assume that all the planets form a perfect line on one side of the Sun we can calculate the *relative* sizes of the tidal effect on the Earth. This is shown on the second column of numbers in Table 1.

Now we see that the Moon is a bit more important than the Sun, just because it is so close. The other planets are now far less important because they are relatively far away. Because distance is so important, the small changes in distance caused by the fact that the orbits are not quite circular becomes significant. So water tides are bigger when the Moon is closer in its orbit. This difference is tens of thousands of times bigger than the whole tidal effect caused by Jupiter!

All this is important! It *does* have an effect. You may know that the Moon always shows us the same side. Did you know that the length of the Earth's day was only about 8 hours when life arose on Earth, and the moon is slowly spiralling away from the Earth? All these are the effects of tidal forces (see Phil Plait's explanation).

Do the tidal effect of planetary alignments cause severe effects on the Earth? No. When a planetary 'alignment' occurs, the planets don't line up all that well, as seen above. Even if they did, the combined tidal force of the other planets is not much more than the effect of a 747 aircraft cruising overhead!

Forces on the Sun

Just for completeness we should consider the effects on the Sun, since that was considered in *The Jupiter Effect*. These can be readily calculated too, with results shown in Table 2. In this case, Jupiter and the inner planets are the main contributors of tidal forces. However these planets go around the Sun relatively quickly and so the possibility of alignments is relatively high. If we simply consider when Mercury, Venus, Earth and Jupiter line up on one side of the Sun, then an alignment to within a span of only 10 degrees occurred in January 1990 with no apparent ill-effect.

Table 2 : Forces on the Sun due to the Planets		
Body	**Relative Gravitational Force**	**Relative Tidal Force**
Mercury	0.031	0.42
Venus	0.13	0.96
Earth	0.085	0.44
Mars	0.0039	0.013

Jupiter	1	1
Saturn	0.088	0.048
Uranus	0.0034	0.00028
Neptune	0.0016	0.00016
Pluto	0.00000014	0.00000002
Assuming all planets at their average distance from the Sun and in a line		

Links

There are several good sites on the web with further information on planetary alignments, and 5 May 2000 in particular (there are even more silly sites). Some of the good ones are:

- John Mosley's page from Griffith Observatory has excellent information on the alignment and an interesting discussion on the silliness surrounding such things.
- Jean Meeus *Sky & Telescope* article listing planetary alignments over time.
- PR page from Sacramento Peak Observatory has some details not found elsewhere.
- Truman Collins' calculations of the gravitational forces on 5 May 2000.
- Brian Monson's movies of the planet motions in April/May 2000.
- 'Ask the Astronomer' answers questions about the planetary conjuction, from the Astronomy Cafe site.
- Phil Plait's discussion from his 'Bad Astronomy' page.
- Solar System Live web-based orrery to show the positions of the planets any time.

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