Features of Nibirum
&
Events To Be Seen In Its Night Sky

Solar Circles on Nibirum

The choice of setting Nibirum's ecliptic at an angle of 25° to its equator, to help provide the planet with Earth-like seasonal changes (Earth's ecliptic is so-angled at about 23½°) also means four "solar circles" can be defined on the planet, two **Tropics** and two **Midnight Sun** lines.

The ***Tropics*** are the northern and southern limits for where Nibirum's Sun annually passes directly overhead at noon, lying respectively 25° north and south of the equator. On Earth, these are named for two zodiacal (= near-ecliptic) constellations that once played host to our Sun at its most northerly and southerly points during the year, the Tropic of Cancer and Tropic of Capricorn.

The ***Midnight Sun*** circles set the limits for those near-polar regions from where the Sun is always above the horizon during that hemisphere's summer, at least briefly, and conversely from where it never rises during the same hemisphere's winter. These lie at 25° from each of Nibirum's rotational poles - so at latitudes 65° north and south of the equator respectively. On Earth, these are called the Arctic Circle and Antarctic Circle.

Nibirum's Geomagnetism

During the Solar System creation process, Nibirum was allocated a magnetic field quite like Earth's, and the System's Sun was similarly determined as being able to emit materials capable of generating auroral activity on Nibirum, when those materials should interact with the planet's magnetism and outer atmosphere. A dipolar magnetic field for Nibirum also means magnetic compasses, from simple suspended magnetic lodestone forms through to more sophisticated devices, will function much as they do on Earth for navigation, for instance.

Detailing Nibirum's geomagnetism further is hampered thanks to how poorly-understood is Earth's own magnetism. However, and in general, magnetic compasses on Earth point only in the approximate direction of the closer pair of magnetic poles. There is indeed *two* such pole-pairs for Earth.

Pair One, The Magnetic Poles (or Magnetic Dip Poles): These are the points on the Earth's surface where a magnetic compass needle would theoretically point straight down into the planet. Hence "Dip Pole", as the magnetic dip-angle is at maximum, 90°. Earth's North Magnetic Pole currently (2018) lies about 5° from the rotational pole around the 180° longitude line over the Makarov Basin of the Arctic Ocean. It has been heading north

from the islands off northern Canada over the last 25 years or so. The South Magnetic Pole is roughly 200 km off the Adélie Coast of Antarctica over the Dumont d'Urville Sea, about 25° from the rotational pole, and has been thereabouts for the past 35 years now.

Pair Two, The Geomagnetic Poles: Simply put, these are more or less statistical constructs based on the assumption that the Earth's magnetic field can be understood as a basic dipole magnet system. Like the Dip Poles, these are not fixed, as they rely on measurements of the global magnetic field as well, but they are overall more stable than the Magnetic pair. They are angled at about 10°-11° to the rotational axis. The South Geomagnetic Pole is presently some 200 km polewards of the Russian Vostok base in East Antarctica, while the North Geomagnetic Pole lies about midway along the Nares Strait between northern Greenland and the eastern coast of Canada's Ellesmere Island.

Interestingly, when examining observations of Earth's auroral activity, and defining zones of relative frequency for surface sightings of that (allowing for the weather, and the uneven distribution of observers), these zones seem to be centred roughly midway between the two pairs of poles.

Nibirum's Magnetic Poles: Following the spirit of the Nibirum experiment, keeping things relatively straightforward for easier RPG use, it seemed sensible to circumvent our current relative Earthly ignorance, and settle on just one "combined" pair of magnetic poles for Nibirum, angled at 10° from the rotational axis in a diametric offset (so the line between them passes through the planet's centre), as illustrated on the geomagnetic map in the *Community Atlas*, along with the main auroral zones.

These auroral zones were based on Earthly statistics compiled from observations made over the past century or so, adapted, amended and simplified for use on Nibirum. While auroral displays may be seen beyond these areas, they are far less often reported from such places.

Working polewards from the outer edge of the Mid-Latitude Aurora Zone, the pale pink circle at 40° from the Magnetic Pole shows where there is an average 1% chance of seeing some auroral activity from the surface on any given night of the year, so perhaps 3 or 4 such displays per year. Some years of course could be better, others worse than this rate, plus the sky needs to be clear and dark enough (with little twilight, for instance) for the aurora to be detected, comments that apply equally across the other Aurora Zones.

The chances of seeing an auroral display increase quickly from here moving towards the Magnetic Pole, reaching an average of 25% nights per year for places along the dark pink circle at the outer edge of the Polar Aurora Zone, 30° from the Magnetic Pole. This equates to auroral events being seen on 90 nights or so each year, while the maximum frequency of sightings, averaging 250 nights per year (70%) is achieved around the centre of the Polar Aurora Zone only, at *circa* 22.5° from the Magnetic Pole, along the narrow dark pink circle line in mid-Zone there.

Sighting frequencies decline closer to the Pole across the rest of this Zone, dropping back to 25% by the dark pink circle on its poleward side, 15° from the Pole itself. They continue to fall across the High-Latitude Aurora Zone, reaching just 1% of nights again along the innermost pale pink circle on this Zone's pole-side limit, some 10° from the Magnetic Pole.

Types and Appearances of Nibirum's Auroral Displays

Drawing as usual on reports from Earth, there are three main types of auroral display that may be seen overnight from Nibirum. (The daytime sky is much too bright for aurorae to be still visible then. Remember that much of the polar regions have very long to continual periods of daylight in summer, so this restricts the available number of genuine "nights" on which the aurora could be seen.) These auroral display types can be loosely determined by the observer's location as compared to the Magnetic Poles: the Polar Aurora, Mid-Latitude Aurora and High-Latitude Aurora.

The Polar Aurora: These displays are visible primarily from the marked zones, from where they may persist for much of the night sometimes. They occur very frequently through the year when the sky is sufficiently dark (up to nightly for days at a time for any given surface location). Such aurorae are usually bright and obvious, often green in colour (though red, yellow, blue-purple and white can occur as well), and form in one or more broad bands or arcs that cross the sky from roughly east to west. These structures may lie in the poleward or anti-poleward side of the sky, or they may pass directly overhead. Commonly, they can have rays extending upwards from the band or arc, rather like searchlight beams. Often, the lowest border of a band or arc in the display can be quite sharply-defined, but the upper parts can become diffuse and formless. The shape and character of both individual forms and the entire display can change very quickly (in a matter of seconds sometimes), so it can seem the whole display is in near-constant motion. Typically, much of the sky can be affected by a display of this kind. On Earth, this is the type of auroral display most frequently shown in TV documentaries, because its brightness makes it easier to film, while its activity makes it more interesting to watch in short segments.

The Mid-Latitude Aurora: Auroral events here are far less common or predictable than in the Polar Aurora Zone. They are also typically fainter, less active, and show a somewhat different range of forms than the polar type. Statistically for Earth, aurorae in this region are more frequent within roughly 50 days to either side of the equinoxes, and are more likely to happen within an hour or two of 10 p.m. local solar time (that is, time based on the Sun's position in the local sky or below the horizon, what we might think of as "sundial time", not standardised, idealised or mechanical clock-based variants). However, such statistics need be treated as only a very loose guide for Nibirum, where the RPG-storyline significance will always outweigh any practical realities, after all.

Forms, colours and appearances can be all quite variable in the mid-latitude aurora, and while they can look something like the polar kind at times, they do not do so with any consistency. A vague white or pale green glow along the poleward horizon, with a few similarly pale rays, might be all that is seen, or an arc or a band, commonly fragmentary, maybe with some rays on it, and perhaps yellow, red, or more rarely blue-purple in colour, possibly only in places, if the display becomes bright enough. The glow-type aurora can persist unchanged for hours on occasion, while the more distinct, or the rarer, more actively-moving types, tend to be shorter-lived, maybe half an hour or so at most. Many displays show only slow changes.

Less commonly, a mid-latitude display may extend over the poleward half of the sky or beyond, extremely rarely growing to cover the entire sky. Such a huge storm often shows linear ray-lines extending from the horizons up to a small area about 5° to 10° across that forms a little way (about 10°-15°) from the zenith, or true overhead point, on

the further side from the pole. This display type may show multiple colours in different places, or may be of dominantly greens and reds. Its striated appearance can give the impression of being inside a gigantic, all-sky, circular tent, the lines like fabric folds gathered together into a central tie almost overhead in its "roof". The convergence point is sometimes called a *corona*, crown, because the rays angling away from it on all sides give it a crown-like shape. This area may have a ring, spiral or eye-like form instead, and it can seem to change shape quickly, so making for both a memorable real-world event, and an excellent plot-device opportunity for RPG GMs!

A mid-latitude storm of such full-sky proportions might be seen down to the tropics, and perhaps even the equator, although if so, probably only briefly there, and most likely as an odd red glow cast across the lower poleward sky or skies (that is, maybe on both southern and northern horizons at once). From mid-latitude sites, an all-sky storm would last for several hours at least, possibly all night, and might even continue into part of the following one, if perhaps at a less intense level. Conversely, the normal polar-zone aurora might not be seen at all during such a storm, because the energetic auroral activity has pushed too far from the Magnetic Poles.

The High-Latitude Aurora: Polewards from the Polar Aurora zones, there is a decreased chance of seeing the aurora, with Earthly statistics suggesting aurorae here can be rarer than in the equator-side regions of the Mid-Latitude Aurora zones. When anything is seen from here, commonly it will be in the equatorwards side of the sky too - so in the southern skies for the North Geomagnetic Pole area, the northern sky for the South one. Forms and appearances can include all elements from either the Polar or Mid-Latitude auroral types, although all-sky displays are rare.

More Events in Nibirum's Night Sky

While these are not things that can be charted or mapped, to add further interest, not to say RPG plot-devices, to Nibirum's night sky, the following notes cover three topics for things GMs may wish to employ in their games using the Nibirum system - Comets, beyond the minor ones of the Dawn Heralds group commented on previously when describing the Solar System's planets; Meteors or Shooting-Stars of various kinds along with sky-fallen Meteorites; and Novae, new stars of up to exceptional brilliance.

Comets

For Earth, bright comets that are easily visible in the night sky to anyone, are rare, although there is evidence for occasionally increased numbers at times for still unclear reasons. Statistically-useful data are available from Earth during the past two millennia. Drawing on the pre-telescopic era, as a comparison period suitable for a fantasy RPG world like Nibirum, restricts this data to the 1st to 17th centuries CE. While there are uncertainties as to what exactly some reports were of (so there can be different values claimed in the scholarly literature), a general overlook suggests that during that time, between 2 and 15 such comets were seen per century, some maybe only by specialists, averaging 6.6 per hundred years, so roughly one obvious comet every 15 years or so. Throughout all that time, just one comet was repeatedly, if inconsistently, seen, Comet Halley. (However, even its recurrent nature at approximately 76-year intervals, was first suggested only by Edmund Halley himself in the late 17th century, and not fully realised until the comet returned as he had predicted in 1758, 16 years after his death.) These

values could be used to make informed choices regarding the possible frequency of similarly impressive comets visible from Nibirum.

Most such comets would be likely seen for just a few days at their best, maybe up to 15 or 20 days. Only a truly exceptional comet would remain obvious for much longer than this. Even rarer - say between one in five to one in ten visible comets - would become bright enough to be seen in the daytime sky, albeit likely only for a day or two at most, again based on Earthly reports.

Although a bright comet might be seen in nearly any part of the sky, comets overall tend to be brightest when nearer the Sun, so are more likely to be first spotted in the morning or evening twilight, relatively close to the ecliptic (say 30° to 40° away at most). In terms of the speed and direction of its movement after that initial sighting, and its appearance, Earthly examples can be readily invoked once more, given that few comets remain on-view for long, so complex orbital calculations for the Nibirran cases should not be necessary - barring a GM's natural desire for more knowledge!

Most comets seen from Earth when at their closest to us, and brightest, move between 1° to 4° across the sky per day (closer = faster), dependent on both their distance and line-of-sight to the planet. This is a reasonable range for most comets seen from Nibirum too, although a very rare comet could move faster than this, if required. The majority will move in the same general direction as the planets as well, though line-of-sight can cause apparent anomalies, while the relative proximity of some may create an unexpectedly strong north-south or south-north component at times too.

Comets have been long a source of omen-lore for Earth, largely due to their unpredictable appearances, physical forms (similar to a long-haired human head), and sometimes unusual behaviour - suddenly brightening, or fading, or moving in an odd manner compared to the planets. There seems no reason why this should not be true elsewhere, if you wish to consider them part of the Nibirum Solar System.

Meteors & Meteorites

From Earth, we see a constant drizzle of tiny dust particles zipping into our atmosphere every night, as short-lived streaks of light in the sky, ***Shooting-Stars*** or more scientifically ***Meteors***. For a dedicated visual sky-watcher, an average of about ten of these per hour can be seen, fewer in the evenings around 6 p.m. local solar time, more towards dawn (centred about 6 a.m.). On a handful of nights a year, such meteors may be seen relatively more frequently, perhaps up to one a minute or better for that same observer, while a similar handful of nights per century may bring unusually large numbers of meteors - hundreds to perhaps thousands per hour - sufficient to be obvious to anyone up and about outdoors, and even able to wake sleepers indoors, if many of the shooting-stars are particularly bright, at least for cultures without significant outdoor nocturnal lighting.

Prior to the 19th century CE, there was no understanding that the nights of relatively better meteor activity were annual events, now identified as due to discrete meteor showers, produced by trails of scattered dust left by the passage of a comet previously. Nor was it realised that some of the very strongest events recurred - if somewhat variably in activity - over longer, decadal, timescales. The appreciation that these activities originated with comets was first made and confirmed only in the 1860s.

From the historical records between the 1st and 17th centuries CE, meteor activity strong enough to be easily seen and thought important, was reported 78 times, averaging 4 to 5 events per century, with a range between 0 and 15 events per hundred years. (Note that these numbers come with similar caveats regarding the interpretation of records to

what was mentioned for comets.) Examination suggests only eight meteor showers still recognisable from Earth were responsible for these events, of which just two were particularly dominant, the Leonid (28 events, but only from the 9th century onwards) and Perseid showers (22 events). Guided by such details, we might set an approximate level of one obvious-to-all night of shooting-stars every 20 to 25 years for Nibirum, as a working average.

Meteors come in all brightnesses, but are similar to the stars in that there are many more faint and visibly-unimpressive ones than bright ones. Those showing colours are similar too, with only meteors of 1st magnitude and brighter liable to seem coloured to a visual watcher - including yellow, blue, orange, red, green or purple in a roughly decreasingly-common order.

As an average, maybe one or two meteors per 10 hours of night will reach magnitude -3 or more for any given surface-located witness. (See page 8 of *The Nibirum Solar System* PDF in the *Community Atlas* for more details on this brighter end of the astronomical magnitude scale.) Those meteors able to achieve or exceed the crescent Moon's brilliance, about magnitude -8, chance-by perhaps once in *circa* 20 such night-lengths similarly, based as ever on Earthly statistics.

There is though also a loose daily statistical "peak" in the likelihood of such bright-meteor occurrence, those of magnitude -3 and brighter (sometimes called ***Fireballs*** or more poetically in past times - until the later 19th and early 20th centuries - ***Fiery Dragons***). This "peak" is centred around 6 p.m. local solar time. It lasts for roughly two hours to either side, during which period such fireballs are about two to three times more likely to happen than twelve hours later (when there is a statistical "trough" for these bright shooting-stars).

Most meteors last less than a second. Those visible for more than 5 to 10 seconds are very rare. However, because the size of the incoming object, as well as its apparent speed, affects how long it can survive its fiery upper-atmospheric flight - and as larger meteor particles tend to glow more brightly - these especially brilliant meteors can be sometimes relatively long-lived. This makes them still more memorable, and increases the chance they will have been widely-seen beyond a few individuals.

The majority of meteors are visible only between about 60 to 120 km above the surface. A magnitude -8 or brighter fireball would be bright enough to remain obviously unusual even if seen within a few degrees of the horizon (clouds, haze, trees and rooftops permitting, naturally), so an average 90 km meteor height would allow such an event to be spotted from the surface up to 1000 km away from the point above which it took place, yet be still roughly 5° above the observer's horizon.

While a meteor seen low in the sky like this may seem to have landed in, say, the next field over, clearly it will not have done so. This has of course not prevented all manner of supposedly sky-fallen things having been recovered from places near a witness following such a sighting, as is well-recorded by Earthly folklore. These objects have included fungi, algae, lumps of unusual though still Earthly rocks, through to carved wooden figurines.

Despite this, some of the very brightest meteors are caused by space-objects capable of surviving their fiery passage through the atmosphere to reach the surface partly intact - ***Meteorites***. Determining that a given brilliant shooting-star was really associated with a particular meteorite is often a difficult and painstaking process. Naturally, folklore circumvents this by making assumptions regardless of evidence, so a few actual meteorites have ended up linked to bright meteors by this route as well, if often essentially by chance. Very occasionally, and usually in daylight, the link can be made

more directly, if the object lands near a witness, who may or may not have seen the preceding fireball as well (given there will have been a time-delay of at least some tens of seconds between the fireball ending and the object reaching the surface).

Meteorite falls being seen like this are rare. Earthly evidence suggests there should be about one fall per 113 km^2 per year across the planet's surface, an area of around 510 million km^2. Nibirum's surface area is almost 515 million km^2, but this *circa* 113 km^2 region can remain a useful ballpark figure for overall fall-rates there too. However, for both planets, most of that surface is ocean, which is where most meteorites will arrive, rather than more conveniently on land. Even on land, only a tiny fraction is sufficiently densely-populated for a fall to stand much chance of being seen. So the best we can say is the chance of any particular person seeing a meteorite fall is not quite zero!

For Nibirum, and if you as GM wish, the more impressive of these meteoric events could all happen, though they are better employed as specific storyline elements, being too uncommon to feature as background occurrences otherwise.

Novae, Temporary, or New, Stars

While the planets, aurorae, comets and shooting-stars are all features within a specific solar system, novae are due to something much more distant. In Earth's Universe, they are due to sometimes cataclysmically explosive events in far-off stars.

Ordinary Novae, which become bright enough to see with no optical assistance (where only a very faint star had been previously, one much too dim to be seen that way), are relatively common, happening at a rate of one every two to three years on average since 1848 CE. However, most of these have been quite faint - their mean peak magnitude is about +4.5 - thus only specialists making diligent nightly reports would be liable to have spotted them. Most historical reports of "new stars" prior to the late 17th century have been dismissed as errors, or misidentified comets, by modern scholars thanks to this aspect.

Thus for Nibirum, we might use these values as a basis for what a few expert sages could see and report in their own notes, or we might allow that novae of second magnitude and brighter could be somewhat more widely-seen in places with sufficient interest in events in the night sky. Earthly statistics suggest about one event in this category, ranging from magnitudes +2.5 to -1.0, should occur on average about every 20 to 25 years, for instance.

Beyond these, there is a second class of novae the ***Supernovae***, which again rise from obscurity, but then all become dazzlingly brilliant, very rarely becoming bright enough to be seen in daylight for those who know just where to look. These though are extremely uncommon. Just five have been seen from Earth since 185 CE, so one in every *circa* 370 years on average. Their mean maximum magnitude has been around -5.5, with a range from -3 to -8. These values too could inform the possibilities for Nibirum once more. In either case, nova or supernova, the star appears and quickly brightens to its peak, before fading away again, all within a few days to weeks (depending on how bright it became). Their greatest brilliancy is rarely attained for more than a few days, regardless of this.

As to their causes, that is entirely at GM's choice, since while real-world explanations have been proposed, many such events are still not fully understood. Whether such explanations apply for Nibirum as well depends on whether its Solar System setting is considered more nearly "real" - like Earth's, say, in a galaxy in space - or "imaginative" - perhaps within an immense crystal sphere where the stars are magical lights set on its inner surface, for instance.