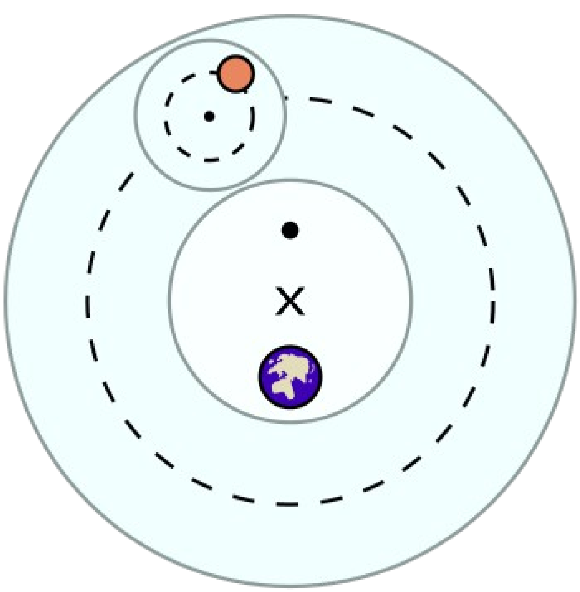
POLARIS

Newsletter of the RASC, London Centre
February, 2019

The Planets in their Courses

Every morning I walk the dog at about 6:15 and for the past month I've been watching Venus slide past Jupiter and head for Saturn, with the moon scooting past all of them. It got me to thinking about Copernicus, Brahe and Kepler, and how those men and others procided the 'key' as to how the solar system worked.

Before Kepler there was Copernicus and before him was Claudius Ptolemaeus (Ptolemy) and other stretching back into history. The first models came from Aristotle et al. and had the various planets attached to crystalline spheres that turned about the Earth. The 'fixed stars' were attached to an outer sphere which was surrounded by a 'prime mover' that was the source of all motion in the universe.



Ptolemy put the Earth at the centre of the solar system (and hence at the centre of the universe) with all the planets orbiting around it. He moved the earth slightly offset from the centre and all the planets orbited a point away from the earth he called the eccentric (X at left). This was to try to take into account why one 'half' of the year was longer than the other 'half'. He was the first to use the terms 'retrograde' and 'prograde' when it came to the motion of the planets and his model had the planets orbiting in two spheres called the deferent and the epicycle. The deferent was the track of the planet around in its orbit and the epicycle was a small orbit that the planet followed around a point on the deferent. This was in an attempt to try to explain apparent retrograde motion.

Copernicus moved the earth from near the centre of the solar system and had all the planets orbiting the a point near the Sun (the equant again). This system was no more accurate than Ptolemy's as it still used circular orbits, but it was much less complicated. Retrograde motion in the Copernican model was explained by the motion of the earth and the fixed stars were set to be a great distance from the sun.

Ellipses.

The ellipse was first studied by Menaechmus then written about by Euclid. The name was given the form by Apollonius and Pappus considered the focus and directrix (not discussed here).

An ellipse isn't just a flattened circle, it has a specific form and they're very simple to draw. Place two tacks in a piece of paper and tie a piece of string into a loop. Place the loop around the tacks, stretch it tight with a pencil and draw a figure around the two tacks keeping the string taught. You have an ellipse. The closer the tacks are the 'rounder' the ellipse looks and when the two tacks are in the same place you get a circle (just a special type of ellipse). The two tacks are the ellipse's two foci.

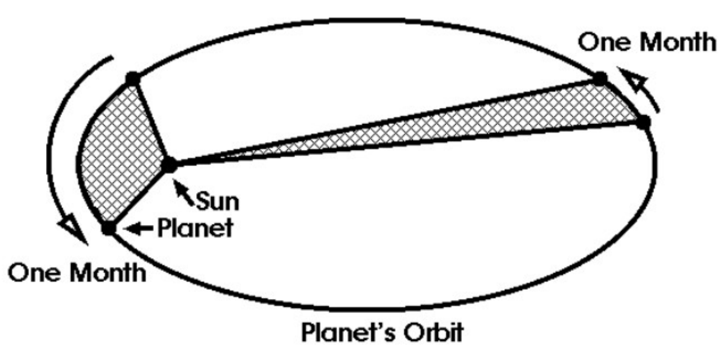
From the above an ellipse is defined as being the locus of all points where the sum of the distance from two fixed points (foci) is a constant. The long axis of an ellipse is known as the major axis and the short axis is known as the minor axis. The semi-major axis is one half of the major axis and in a circle would be called the radius.

The shape of an ellipse is dictated by the length of the semi-major axis and the eccentricity, or how 'not round' the ellipse is. This is defined most simply as the ratio of the distance from the centre of the ellipse to each focus (c) and the semi-major axis (a); therefore $e = c/a$. There are many more definitions but this one will do for our use.

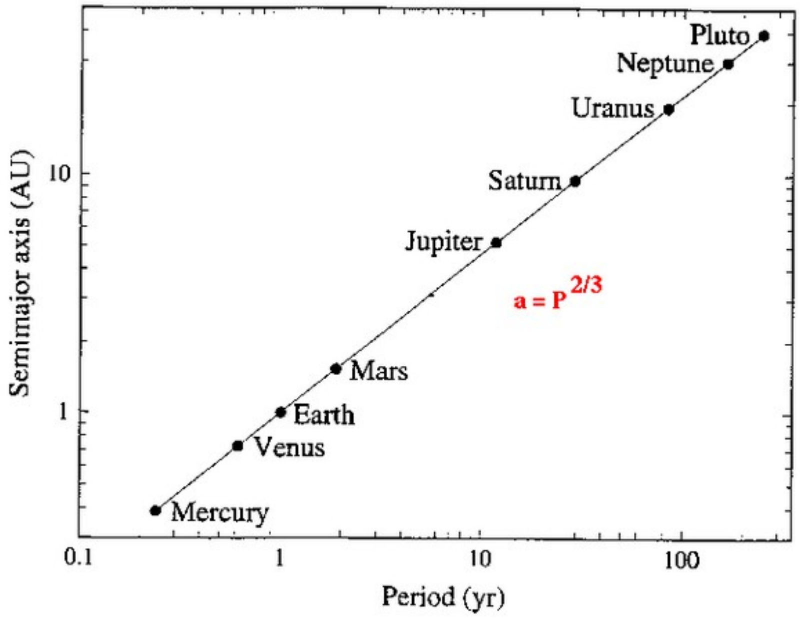
Kepler's determinations

It took Johannes Kepler, using a great trove of data collected by Tycho Brahe to bring the solar system into line by discovering his three laws:

1. The orbit of a planet is an ellipse with the Sun at one of the two foci,
2. A line joining the planet to the Sun sweeps out equal areas in equal times, and



3. The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit.



Kepler, being a pious man, was not much different that anyone else at the time and thought that the circle was a mystical shape that was determined by divine plan and that the planets SHOULD be travelling around the Sun in circles. Using Tycho's observations he came to the realization that this was indeed, not the case as he could find no circular orbit that fit the data. Looking at the diagrams he made for the orbit of Mars he found that if a line drawn from the Sun to a planet's orbit and then another was drawn a certain amount of time later, that the area enclosed by the orbit and the two lines would be the same anywhere on the orbit so long as the amount of time was the same (his 2nd law). This discovery led to his determination of the 1st law, that the orbit is in ellipse and the Sun is at one of the foci.

Remember, this all had to be done empirically. At the time there were no general theory of gravitation or calculus to help; those had to wait for Newton. All that Kepler had were Tycho's observations of the planets and the mathematics of the time.

Once he had laws one and two nailed down, he could derive the distances of the planets from the Sun. It was not long before the 3rd law, or Harmonic Law, became clear to him.

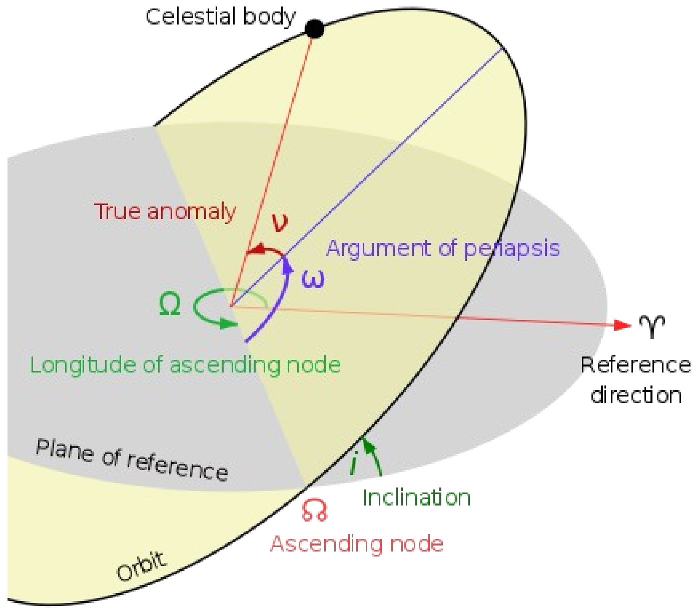
Orbits

Now that we know that orbits are ellipses, and that ellipses are described by their size and eccentricity we can look at some other values that we use to properly position a planet in space.

First, some definitions

Reference plane	*For the solar system the plane of the ecliptic.*
Ascending node	*Where the orbit crosses the reference plane from south to north*
Perihelion	*The closest point of the orbit to the Sun*
Vernal equinox	*The point on the plane of the ecliptic where the sun crosses from south to north*

An orbit is described by six elements. Two, the Keplerian elements, describe the size and shape. These are, as mentioned above, the semi-major axis (a) and the eccentricity (e).



Two more describe how the orbital plane is oriented. These are the inclination (i), or how much the orbit is tilted to the ecliptic and the Longitude of the Ascending Node (Ω) which is measured from the vernal equinox.

The last two elements are the Argument of Perihelion (ω) which is the angle measured from the Longitude of the Ascending Node to the Perihelion and the True Anomaly (ν) which is the position of the planet along the ellipse at a specified time (the epoch).

These six elements will allow you to properly position any orbiting body in the solar system at any given time (sort of). For perfect (unatainable) accuracy you have to take into account the gravitational fields of all the other planets, minor planets, dwarf planets etc. etc. in the Solar System. But this is good enough.

After Kepler came Newton who, thinking on apples and the Moon, developed his theories of gravitation. Taking into account Kepler's laws he was able to show that gravitation acted radially on the planets from sun with a force of $G = Mm/r^2$. This, along with his and Leibnitz's calculus allowed much better models of the Solar System to be made.

Note: If you wish to do some orbital calculations yourself I recommend to you Practical Astronomy with your Calculator by Peter Duffet-Smith (try Abebooks). If you can get your head around PERL I have all the functions somewhere on a hard drive that will help out.

RASC London Centre Library

As always, these "Books of the Month" are available for loan to members, to be returned at the following monthly meeting. The books for February 2019 are as follows:

In Search of Time: Journeys Along a Curious Dimension, by Dan Falk. c2008.

Universe on a T-shirt: the Quest for the Theory of Everything, by Dan Falk. c2002.

365 Starry Nights: an Introduction to Astronomy for Every Night of the Year, text and illustrations by Chet Raymo. c1982.

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If there is anything you wish to borrow from the Library, please feel free to contact me by telephone at (519) 439-7504 or by e-mail at **rduff@sympatico.ca**

Outreach

Cronyn Observatory Public Nights, Exploring the Stars & Special Events, January—February 2019

Total Lunar Eclipse at the Cronyn Observatory, Sunday—Monday, January 20th—21st, 2019

Exceptionally clear skies and very cold (–19 degrees Celsius) weather greeted some 350 visitors to Western University's Cronyn Observatory for the Total Lunar Eclipse, Sunday—Monday, January 20th—21st, 2019, 10:00 p.m.—1:00 a.m. The partial eclipse began with the Moon entering the Earth's umbral shadow at 10:33 p.m. EST (03:33:55 UT). Totality was from 11:41 p.m.—12:43 a.m. (04:41:19—05:43:18 UT), January 20th—21st, with greatest eclipse at 12:12 a.m. (5:12:18 UT), January 21st, 2019.

Professor Jan Cami and graduate student Viraja Khatu organized the event which included (1) viewing the eclipse with the 25.4cm refractor in the dome and amateur telescopes set up on the observation deck; (2) a cloudy sky back-up plan of slide presentations around 10:15 p.m. and 11:15 p.m.; (3) a "Coffee Stop" of coffee and hot chocolate for people to warm up; (4) demonstrations of the *"Spectroscopy Demonstration,"* in the downstairs *"Black Room"* and tours of the historic *"Period Rooms."*

RASC London Centre was represented by Everett Clark, Henry Leparskas and Bob Duff, later joined by Mohammed Mubeen, who brought his Sky-Watcher 8-inch (20.3cm) Dobsonian. Henry set up the RASC London Centre's 25.4cm Dobsonian on the observation deck before going downstairs to give tours of the *"Period Rooms."* Everett helped set up the "Coffee Stop" and table for the Space Society of London (SSoL) bake sale just inside the door and on the right, at the back of the lecture room. Viraja placed 200 *"Total Lunar Eclipse, Hume Cronyn Memorial Observatory, Sunday, January 20, 2019"* pamphlets on the slide projector cart for distribution to visitors.

The visitors arrived early with Bob Duff counting 17 people in the dome and 19 in the lecture room by 9:50 p.m., and 7 more in the downstairs *"1940s Period Room"* at 9:57 p.m. Physics graduate student Farnoush Attarzadeh soon took over the visitor count for the evening. There were 67 visitors in the lecture room and 40 in the dome by 10:03 p.m. Professor Jan Cami gave 2 presentations of his slide presentation *"The Super Blood Wolf Moon of January 20, 2019."* There were 82 people in the lecture room at 10:20 p.m. for the first slide presentation and 80 people at 11:00 p.m. for the second slide presentation. The total count for the evening was estimated to be 350 visitors. Graduate student Hadi Papei showed visitors the lunar eclipse through the 25.4cm refractor in the dome (52mm Erfle eyepiece, 84X) for most of the evening. There was a big line-up of visitors inside the dome and all the way down the stairs.

Viraja gave 6 demonstrations of the *"Spectroscopy Demonstration,"* in the downstairs *"Black Room"* and Henry Leparskas gave tours of the historic *"1940s Period Room,"* the *"1967 Period Room"* and the *"W. G. Colgrove Workshop Period Room."* The 3 "*Period Rooms"* were designed by RASC London Centre member Mark Tovey. Henry also gave the *"Spectroscopy Demonstration,"* to 2 groups after Viraja took a break.

Bob operated the London Centre's 25.4cm Dobsonian (17mm Nagler eyepiece, 66X), showing visitors the eclipse as the distinct grey shadow of the Earth (with a hint of red) moved in across the face of the Moon. Mohammed Mubeen set up his Sky-Watcher 20.3cm Dobsonian (25mm Plossl eyepiece, 48X) along with his Nikon D7200 DSLR camera with a 300mm lens, set up on a tripod. Some visitors took pictures of the camera's live view screen. Mohammed also brought his 10 x 50mm binoculars for people to view the eclipse. Mohammed, and later Hadi, took over the 25.4cm Dobsonian when Bob took time off to warm up indoors. Viraja took over the 25.4cm refractor in the dome when Hadi went outside to operate the 25.4cm Dobsonian.

Professor Jan Cami handed out 150 of the *"Total Lunar Eclipse"* pamphlets and took over operation of the 25.4cm Dobsonian for the last 30 minutes of eclipse totality. There were 240 cups of coffee and hot chocolate served throughout the evening. The visitors were gone by around 1:00 a.m., Monday morning, January 21st, after a very enjoyable and exciting evening viewing the eclipse through telescopes under very clear skies.

Cronyn Observatory Public Night, Saturday, January 26th, 2019

Cloudy skies greeted some 69 visitors to Western University's Cronyn Observatory Public Night, Saturday, January 26th, 2019, 7:00 p.m. Graduates student Ben George made his digital slide presentation *"Low Mass Stars and Their Potential for Finding Planets"* and fielded questions. RASC member Bob Duff counted 43 people around 7:03 p.m., in the lecture room at the beginning of Ben's presentation, increasing to 54 visitors by 7:20 p.m. More people arrived throughout the evening for a final count of 69 visitors.

RASC London Centre was represented by Everett Clark, Henry Leparskas, Mohammed Mubeen and Bob Duff. Since it was cloudy, graduate student Hadi Papei showed visitors the lights on the communications tower in south London through the big 25.4cm refractor in the dome (17mm Nagler eyepiece, 258X). Everett set up the observatory's 8-inch (20.3cm) Schmidt-Cassegrain (26mm Plossl eyepiece, 77X) inside the dome so as to view out the door to the observation deck, directing it towards the TV screen visible in the Western Sports & Recreation Center windows. Everett and Mohammed supervised and talked with visitors as they looked through the 20.3cm Schmidt-Cassegrain.

Towards the end of the evening Bob gave one couple a tour of the big 25.4cm refractor, explaining the Schmidt camera and Cassegrain reflector piggy-backed on the main telescope, as well as the 20.3cm Schmidt-Cassegrain set up on the dome floor. He opened the storeroom and showed them the RASC London Centre's 25.4cm Dobsonian and explained the difference between a reflector and refractor telescope. He also showed them the 2 clocks on the east wall of the dome and explained the difference between Standard and Sidereal Time.

Downstairs in the *"Black Room"* Henry Leparskas showed visitors the *"Spectroscopy Demonstration,"* with the visitors putting on *diffraction grating* glasses to view the spectra of 4 gas discharge lamps, including hydrogen, helium, neon and mercury. He also showed them the *"Transit Demonstration,"* with the *"Transit Demo"* model—showing how the transit detection method worked for finding extra-solar planets.

Henry also gave tours of the historic *"1940s Period Room,"* a recreation of Dr. H. R. Kingston's 1940 office, with his brass refractor and the *Sotellunium*—a mechanical eclipse demonstration model built by W. G. Colgrove—on display; and the *"1967 Period Room,"* recreating the early control room of the Elginfield Observatory to celebrate the 150th anniversary of Confederation—Canada 150. The *"W. G. Colgrove Workshop Period Room"* was also open for visitors' inspection. The 3 "*Period Rooms"* were designed by RASC London Centre member Mark Tovey.

The dome was closed down around 9:00 p.m., after the last visitors had gone. Henry continued showing the *"Spectroscopy"* and *"Transit"* demonstrations to several visitors until 9:30 p.m., after which the *"Black Room"* and history rooms were closed down. The visitors enjoyed an informative evening, despite the cloudy skies and took 7 *"Star Finder"* planispheres that were available in the *"Black Room."*

Exploring the Stars, 82nd London Guides, February 4th, 2019

Cloudy skies and rain greeted 28 visitors (25 children and 3 adults) from the 82nd London Guides for Exploring the Stars at Western University's Cronyn Observatory, Monday, February 4th, 2019, 6:30 p.m. Graduate student Ben George presented the digital slide presentation *"The Scout / Guide Astronomy Badge,"* with the title slide *"The Basics"* and fielded questions. Ben followed this with the *"Crater Experiment"* activity, inviting the Guides to a table set up at the front of the lecture room, where various size balls were dropped into a pan filled with flour and topped with chocolate powder, to demonstrate impact cratering.

Bringing the group upstairs into the dome, Ben introduced RASC member Bob Duff, who gave a talk on the history of the observatory and technical aspects of the big 25.4cm refractor, using the 52mm Erfle eyepiece (84X) for demonstration. Bob explained the Schmidt Camera and Cassegrain reflector piggy-backed on the 25.4cm refractor and the difference between a reflector and refractor telescope. Bob opened and closed the shutter on the Schmidt camera to demonstrate how it worked. He also called their attention to the 2 small finder scopes mounted on the main telescope and one of the Guides correctly answered that there were, in all, 5 telescopes on the telescope mount. The dome remained closed due to rain, but Ben rotated the dome to demonstrate how it worked. Bob also explained the 2 clocks mounted on the east wall of the dome and explained the difference between Standard and Sidereal Time.

Ben invited the Guides to look through the big 25.4cm refractor aimed towards the ceiling of the dome. Bob showed them the RASC London Centre's 25.4cm Dobsonian (17mm Nagler eyepiece, 66X), which he had set up inside the dome for demonstration and explained how the reflector telescope worked. The Guides were gone from the dome by around 8:00 p.m. and, after returning to the lecture room, left the observatory around 8:30 p.m., after an enjoyable evening learning about astronomy.

Polaris On-Line

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