

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA



SASKATOON CENTRE

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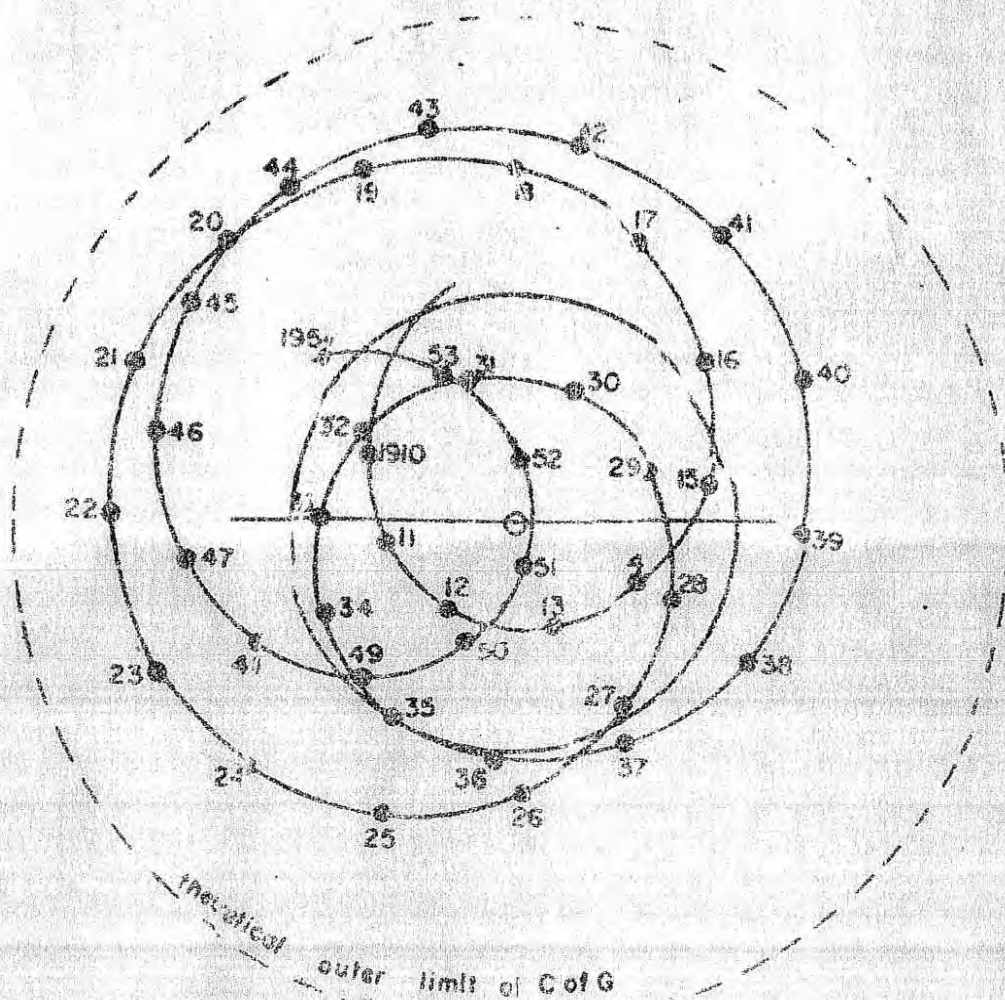
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JANUARY, 1975

# NEWSLETTER

ANNUAL POSITION OF SOLAR SYSTEM  
CENTER OF GRAVITY

1910 - 1954



# THE MANY MOTIONS OF THE PLANET EARTH {Part Two}

G.N. Patterson

## PRECESSION OF THE EARTH'S POLAR AXIS

The Earth is literally a gigantic gyroscope spinning about its polar axis which is inclined approximately  $23.5^\circ$  from the ecliptic pole. Due to the steady off-axis gravitational pull of the Sun on the Earth there is a constant unbalancing force exerted on gyro-Earth, and like any gyroscope exposed to such a force, the axis-of-spin, in this case the polar axis, turns in a direction counter to the direction of spin. Such a motion is termed Precession, and results in a slow but continuous motion of the spin-axis.

In the case of the Earth, the precession rate is about 50.26 seconds of arc per year, taking approximately 26,000 years to complete one entire revolution.

The effect is to gradually shift the position of the celestial pole through various constellations, coupled with a shifting of the vernal equinox. In 13,000 years Summer will be in December with Winter in June, and as the Earth is at perihelion in December, the summers will be warmer then with the winters much colder. Some authorities believe this motion is partially responsible for past Ice Ages. Precession, coupled with Nutation, results in the polar axis describing a wobbling circle about the Ecliptic Pole that has approximately 1400 cycles (Nutations) per precession revolution.

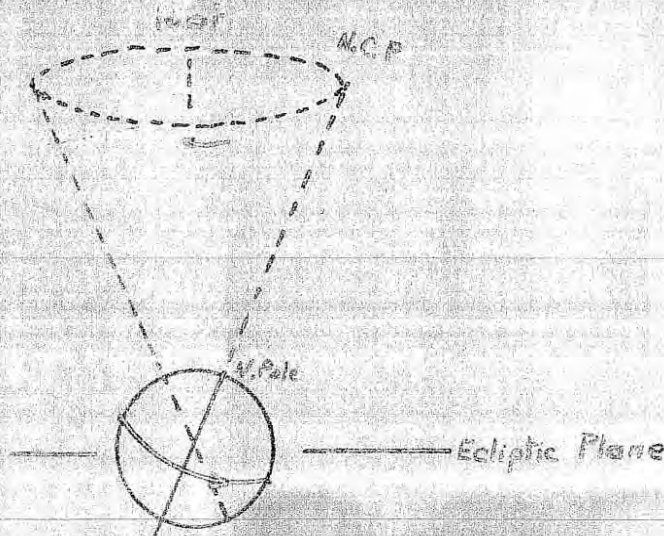


Figure 7: Precession

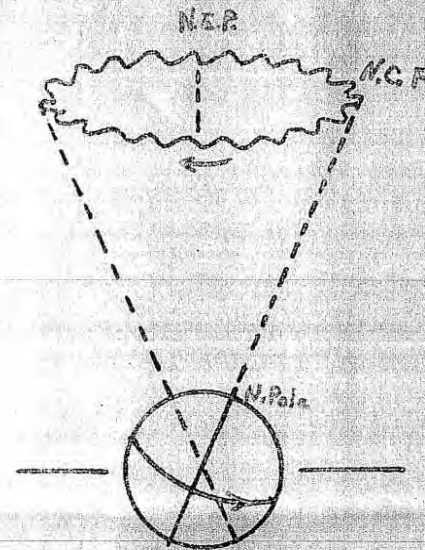


Figure 8: Precession + Nutation

## 6. ROTATION OF OUR SOLAR SYSTEM ABOUT THE CENTER OF OUR GALAXY

Our Solar System is a very minute portion of our Galaxy which we know as the Milky Way. Our Galaxy is approximately 100,000 light years in diameter with our Solar System located about 30,000 light years from the center, or 20,000 light years from the outer edge, See Figure 9.

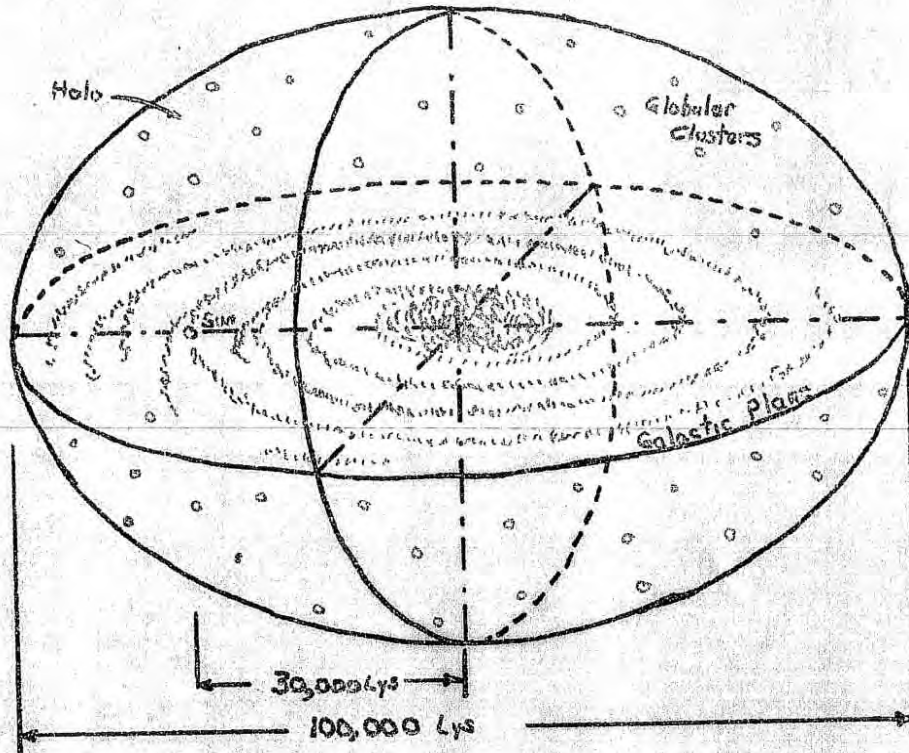


Figure 9: Perspective View of Our Galaxy

All the star systems in our Galaxy rotate about the galactic center with various orbital velocities depending on the distance of each star system from the galactic center. The rotational velocity of our Solar System is approximately 26.2 kilometers per second (16.28 miles/second) with a total rotational period around the Galaxy of  $2.2 \times 10^8$  years. If we now consider the motion of the Earth relative to the galactic center we see that it is, in addition to rotating about the Sun, also advancing with the Sun around the galactic center, and this gives it a motion similar in many respects to that of the Moon about the Earth. See Figure 10. Each year the Sun has advanced 2.75 astronomical units around its galactic orbit, so the Earth participates in this motion, being subject to retrograde motion after reaching perihelion.

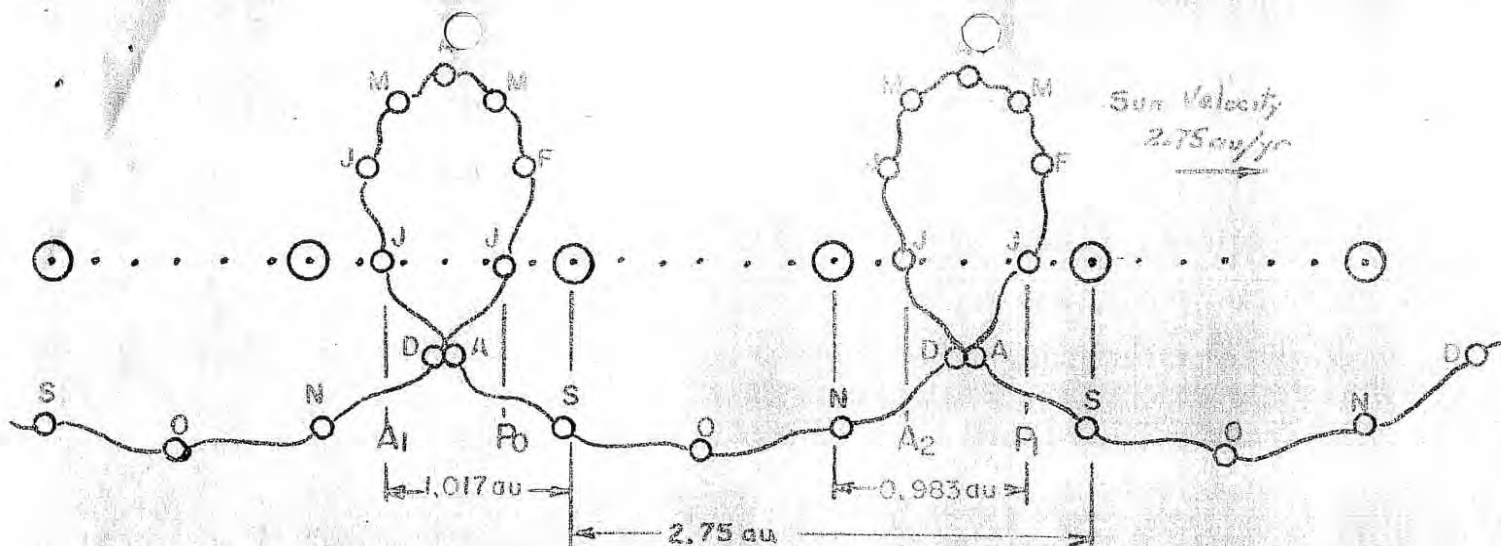


Figure 10: Motion of Earth referred to the Galactic Center

No earlier reference has been made to the fact that our Solar System is actually a multi-planet system. Since the planets have different orbital speeds, their positions relative to each other keep changing, and this effect is noted as a change in the center-of-gravity of the Solar System. This change is shown in Figure 11 (Cover Page) for the years 1910 to 1954. It is the center-of-gravity of the Solar System which follows the galactic orbit, so it can be seen that the actual motion of the Earth is considerably more complex than that shown in Figure 10. To any other nearby solar system our Sun is "perturbed" by the planets, and this is the method used to detect planets on other star systems. Barnard's Star, 5.9 light years distant, is a typical example where modern measurements of perturbations indicate at least two or three large planets are present. Dark companions to other stars have also been detected by their perturbing effect on the visible star.

#### 7. MOVEMENT OF THE GALAXY IN SPACE

Our Galaxy appears to be one member of a cluster of galaxies, and is moving relative to the center-of-mass of this system. Furthermore, all galaxies external to our own show a red-shift in their stellar spectrums indicating they are moving away from our Galaxy. Motion of these galaxies have given some astronomers the evidence they need to support the "Big Bang" theory which implies that all galaxies originated from a common point in

"Space" at the time of the creation of the Universe. However, for all practical purposes these are motions that can be ignored when considering the various motions of the Earth - in other words, the Center of our Galaxy is considered as our Zero Point of Reference.

From the foregoing we see that the total motion of the Earth includes axial spin, rotation about the Barycentre, about the Sun, and about the Galactic Center, all the time being subjected to Nutational and Precessional movement, plus the effect of all the planets on the Solar System center-of-gravity. Truly an extremely complex motion indeed!

Let us look at the combined effect over a period of 100 years. The Earth will have turned on its axis 36,625 times (sidereal days) but this will only amount to 36,525 solar days. In addition the Earth will have turned 1,236.85 times around the Barycentre and Nutated 5.373 times, Precessing through 5026" or 1.396 degrees. During this same time the Earth will have moved 275 astronomical units or 255.6 million miles along its Galactic orbit.

Why are we concerned with knowing the true motion of the Earth? The Earth is our astronomical observation platform, and if we are to be able to predict the future positions of stars and determine their proper motion and/or perturbations, determine the correct speed of galaxies from their spectral Doppler shift, accurately predict eclipses, and determine cometary orbits we have to take into account in all our calculations the motion of our observational platform, the Earth.

If, in the distant future, we ever send astronauts to other star systems, they will have to know where the Earth will be when they have to calculate a return trajectory to their home planet. Fortunately for all concerned we now live in an age of high-speed electronic computers, but such computers are only as accurate as the information programmed into them, so it will be essential for such astronauts to have accurate information on the true motion of the planet Earth.

\* \* \* \* \*

PLACE: Room B111, Health Sciences Building, U of S.  
(across from observatory)

DATE: 21 January, 1975 (Tuesday).

TIME: 8:00 pm

PURPOSE: Regular business and an interesting talk on  
BLACK HOLES by Dr. RAY SKINNER.

all are welcome

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- - - PHYSICS FOR FUN FILM SHOW - - -

Presented by the Physics Department, U of S, Saskatoon, and the Extension Division. These programs are designed for the general public and open to everyone, free of charge.

The next show will be on Wednesday, 22 January, 1975 at 8:15 pm in room 107, Physics Building. Three interesting films will be shown:

Russia Beneath the Sputnik,  
BART - Vision to - Reality, (San Francisco Bay Area Rapid Transit),  
Computers in the Seventies.

- - - ACTIVITIES - - -

Interested members are reminded that:

- 1) Astrophotography classes are being held at Mr. Patterson's home, 79 Baldwin Crescent.
- 2) Fundamentals of Astronomy Theory classes are held on the second and fourth Tuesdays of each month in the University Observatory, starting at 7:30 pm.

Take full advantage of your membership by taking part in centre activities.

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NAGY, Alvin NASHBAR, A.N.	Box 625, Humboldt, Sask. 217 Queen's Hotel	682-3930 244-1101
PALCHINSKI, Debbie PANDYA, Kamlesh PATTERSON, Gordon PATTERSON, James	815 8th Street E. 413 9th Street E. 79 Baldwin Cres. Officer in Charge, Alert Weather Station, Atmospheric Environment Service, Canadian Forces Station Alert, M P O 3 1 0 Belleville, Ontario, K0B 0A0	65-2933 24-0008 374-2511
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WILCOX, T.	2527 Clarence Ave.	343-7462
YING, Eddie	34 Hiel Cres.	373-3808
YOUNG, Jar	2513 Helross Ave.	242-4661

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ANNOUNCEMENT

February 4th at 7:30 p.m. in the Observatory, Wenzel Frenzel will host all of those members interested in PRACTICAL ASTRONOMY. This session will review the operations of the telescope, discuss the possible topics for the class as well as planning for outings to view the constellations or the upcoming astronomical events.



Minutes of the Executive Meeting  
Saskatoon Centre R.A.S.C.  
Sunday December 3, 1974 3:00 p.m.  
Held in the Observatory

Presents:

President	- Halyna Kornuta	Editor	= Greg Towstego
Secretary	- Melodie Andrews		= Dave Pristupa
Treasurer	- Alan Blackwell	Librarian	= Hugh Hunter
Activities	- Wendel Frenzel	VP/PR	= Jim Young

Absent: Programming - Dr. Holden

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26. The meeting was opened, at 3:00 p.m.
27. Program for the December meeting was discussed.
28. Fundamentals classes will be cancelled December 24 and resume January 14. The topics taken now are optics and observing.
29. Physics for Fun films will be January 8 and 22 in the Physics building.
30. Library workshop Saturday January 11, 2:30 p.m.
31. Handbooks will be given out as soon as possible.
32. Meeting adjourned.

Greg Towstego  
Wendel Frenzel

Minutes of The General Meeting  
Saskatoon Centre R.A.S.C.  
Tuesday December 17, 1974 8:00 p.m.  
Held in the Health Science Bldg. Rm. B111

Present:

President	- Halyna Kornuta	Editor	= Greg Towstego
Secretary	- Melodie Andrews		= Dave Pristupa
Treasurer	- Alan Blackwell	Librarian	= Hugh Hunter
Activities	- Wendel Frenzel	VP/PR	= Jim Young

Absent:

Programming - Dr. Holden

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33. The meeting was opened at 8:00 p.m.
34. Adoption of the November minutes  
Wendel Frenzel  
Lee Warner
35. An observing group has been started. This will start on January 7, at 7:30 p.m.
36. Motion for the purchase of the honorary Presidents membership.  
Alan Blackwell  
Wendel Frenzel Carried.
37. The film "The Strange Case of Cosmic Rays" was shown.
38. Meeting adjourned to the observatory.  
Jim Young  
Hugh Hunter