1. **Abstract**
   - Calculate the moon's position over a three-year span and compare its position to the position of Earth's magnetotail and bow shock.
   - Provide information as a decision support table for Deep Space Radiation Genomics (DSRG) Yeast Experiment.
   - Determine if passage through Earth's bow shock poses a concern for altering the ionizing radiation encountered by a yeast experiment.

2. **Introduction**
   - The magnetized plasma of the supersonic solar wind deforms Earth's magnetic field into the magnetosphere.
   - The magnetosphere has a blunt dayside nose extending to about 10 Earth radii (RE) on the sunward side of Earth and a long 'magnetotail' that extends in the anti-sunward direction several hundred RE (See Fig. 1).
   - The moon spends about six days out of every lunar cycle in the magnetotail. Figure 1 shows that Earth's magnetotail swings (aberrates) dusk ward from the Sun-Earth line.
   - Solar wind plasma, which carries a weak interplanetary magnetic field from the Sun to Earth, must slow or brake as it approaches the magnetostail. A bow-shaped shock forms around the magnetosphere to facilitate this braking to subsonic speeds.
   - The interplanetary magnetic field (IMF) is compressed and becomes more structured. The compression of the IMF produces a field gradient that can act as a deflector of low energy particles but can also accelerate particles of certain energies to higher energies.
   - Radiation of biological concern to the human spaceflight program is primarily "ionizing radiation." 
   - Ionizing radiation is produced by energetic particles (charged and neutral) or photons with sufficient energy to pass into and through human tissue; for protons, the threshold energy is ~10 MeV.
   - The energy threshold for concern is typically more like 20-30 MeV.
   - These are the energetic particles that are relevant to the experiment that cannot be disturbed by the bow shock.

3. **Methods**
   - To calculate a python astronomical ephemeris library PyEphem was used, it can calculate the moon's position in right ascension (RA), declination (dec), distance from the earth to the moon, and moon phase.
   - The moon's position then had to be converted from GSE coordinates (RA and dec) to GSE coordinates. The conversion was outlined by Hapgood (1992), which required two transformations in a matrix.
   - The moon's position was then plotted in XYZ cartesian vectors.
   - The magnetotail and bow shock were then plotted as 2D circles at x = ±60Re. The magnetotail's GSE x,y,z components are (x = ±60Re, y = Δy, z = 0) with a radius of 30Re(Earth radii).
   - The magnetotail circle is aberrated in the +y direction defined by y = |xmoon|29/v_sw (Hapgood 2007).
   - The bow shock is centered around the magnetotail with a radius of ~50Re (Sibeck et al., 2014).

4. **Results**
   - Figure 2 shows the results from plotting the moon's position and the magnetotail.
   - The Blue points represent the moon's position that would qualify as a "yes" decision in the table.
   - Purple data points represent a three-day window before the moon enters the bow shock.
   - Yellow points represent the moon in the bow shock.
   - Red represents the moon in the magnetotail.
   - A literature review suggest the bow shock does not have a significant effect on energetic particles relevant to the DSRG effort.

5. **Conclusions**
   - The results from the graphical representations of the moon's position compared to the position of the magnetotail and bow shock illustrated that there were 9-12 days each month when the experiment could not start.
   - Two decision tables were created; one providing 'yes' or 'no' decisions considering only the magnetotail, and another considering the bow shock and magnetotail.
   - Both tables exclude an additional three days to ensure that the experiment can run for a full three days before it enters the magnetotail.
   - It is believed having the DSRG experiment run while passing into the bow shock will not have a significant impact on the experiment.
   - Extreme events that would severely alter the magnetospheric shape occur about once a decade for an interval of 24-72 hours.
   - Predicting such events is beyond current forecasting capability.

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**References**