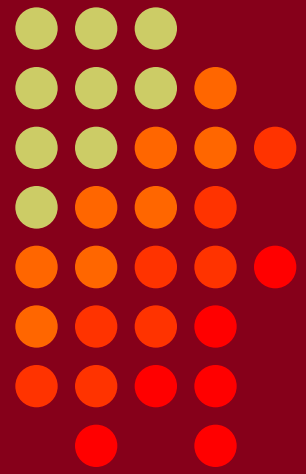
Solar Cycle 25: Lessons Learned for Amateur Radio

Impacts to Propagation in the Declining Phase

Dr. Tamitha Skov WX6SWW



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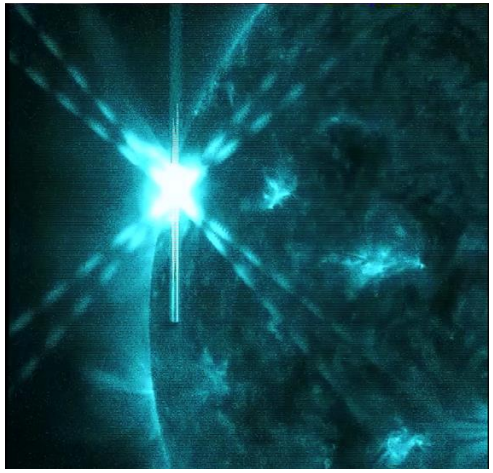
Introduction

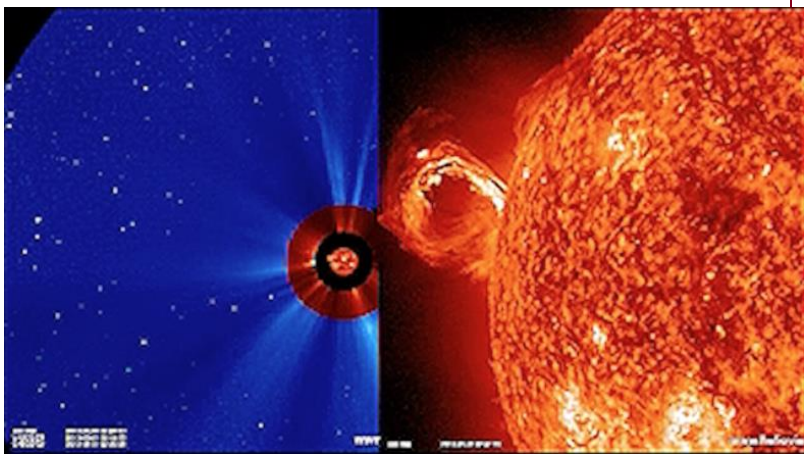
- Solar Cycle 25: where are we now?
- What the declining phase of the cycle means in terms of space weather phenomena
- Coronal hole topology
- Stream Interaction Regions (SIRs) during Cycle 25
- The “Russell-McPherron Effect” and how to use it in forecasts of radio propagation over the next year
- Summary

Basic Types of Solar Phenomena Affecting Earth

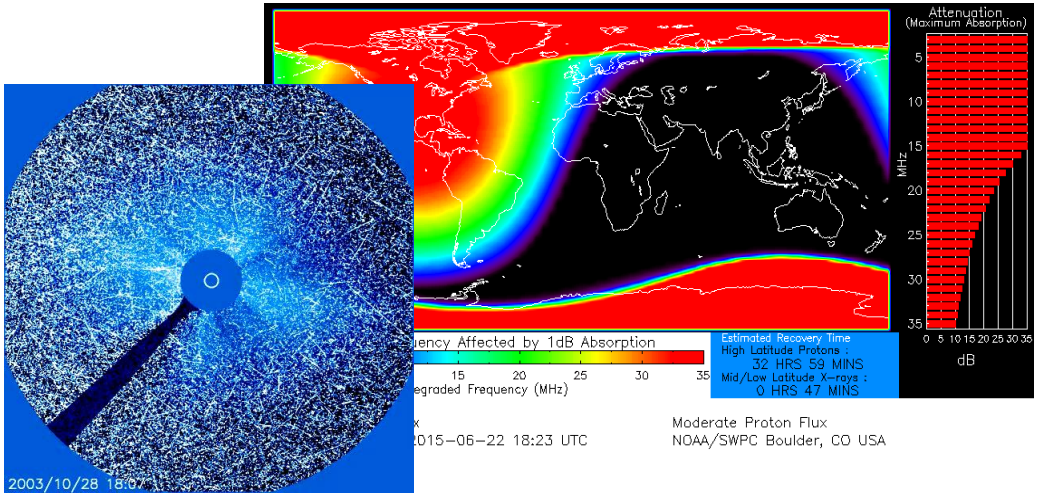
Solar Flares



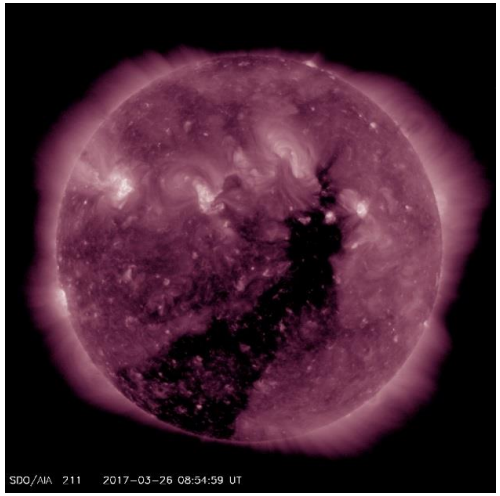
Solar Storms (a.k.a. CMEs)



Solar Radiation Storms (a.k.a. SEPs)



Coronal Holes (Fast Solar Wind)



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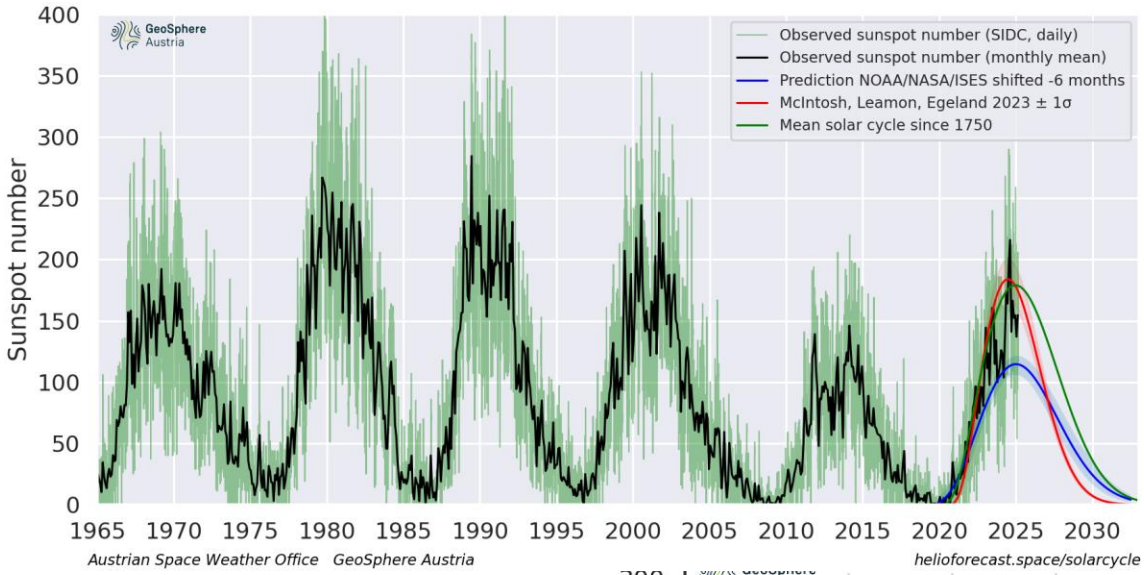
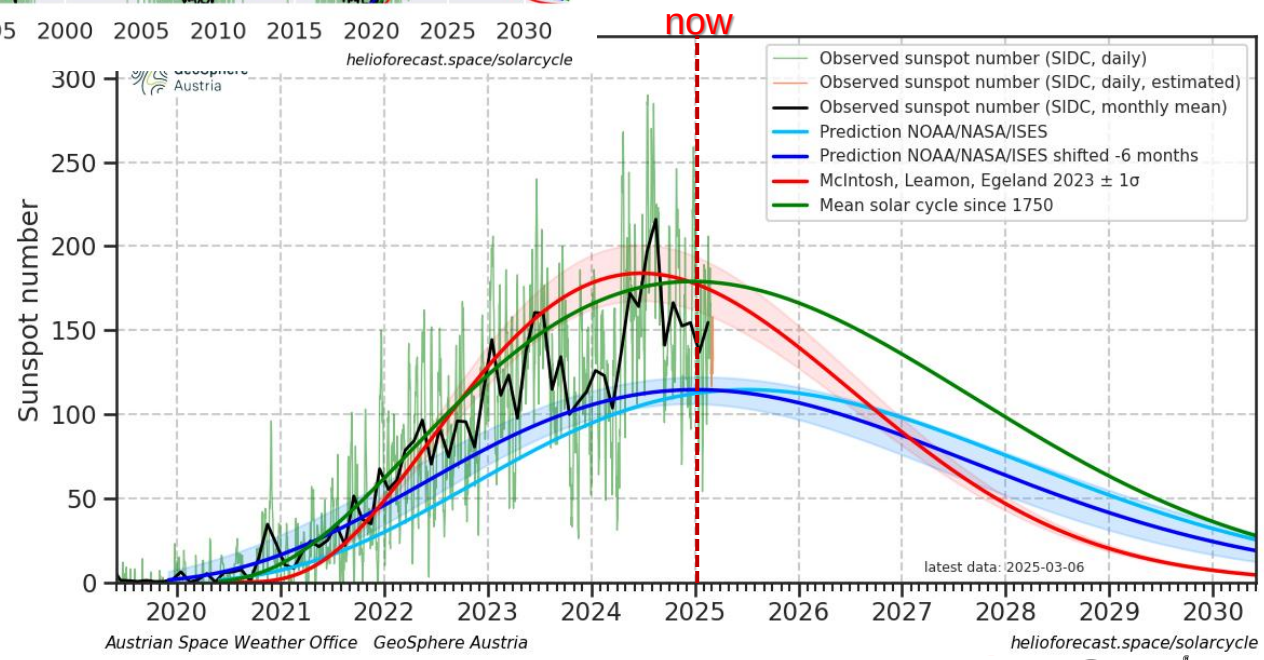
Solar Cycle 25: Where are We Now?



- Sunspot number shows Cycle 25 is larger than Cycle 24
- Activity is similar to “average” cycle
- Solar maximum reached in October 2024

- We are entering the declining phase
- This is when dynamics are the most complex
- A new dipole field competes with the remnants of the old



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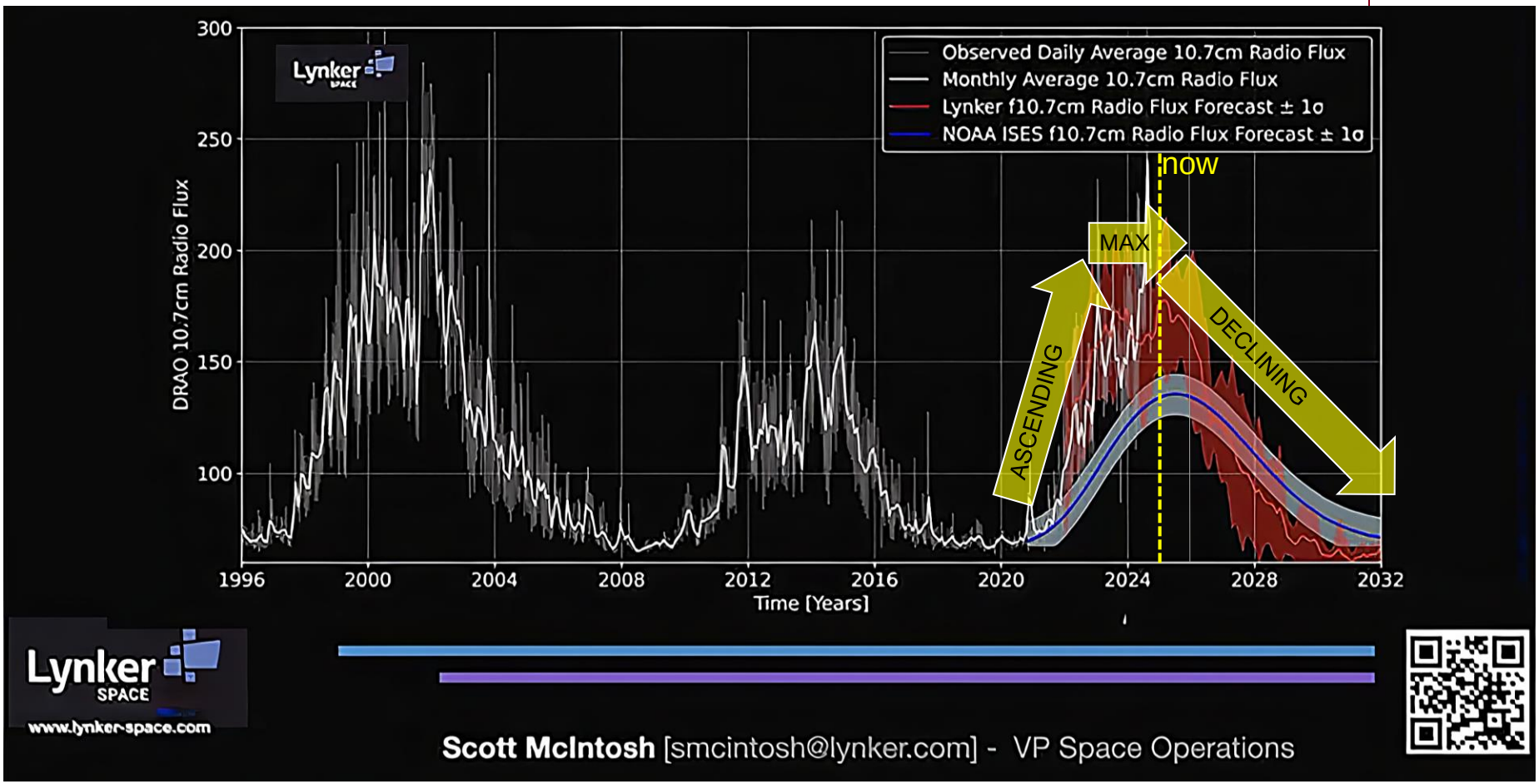
Solar Cycle 25: Where are We Now?

- F10.7cm flux may actually peak higher early in the declining phase
- Lynker-Space predictions show it dropping below 100 mid-to-late 2027



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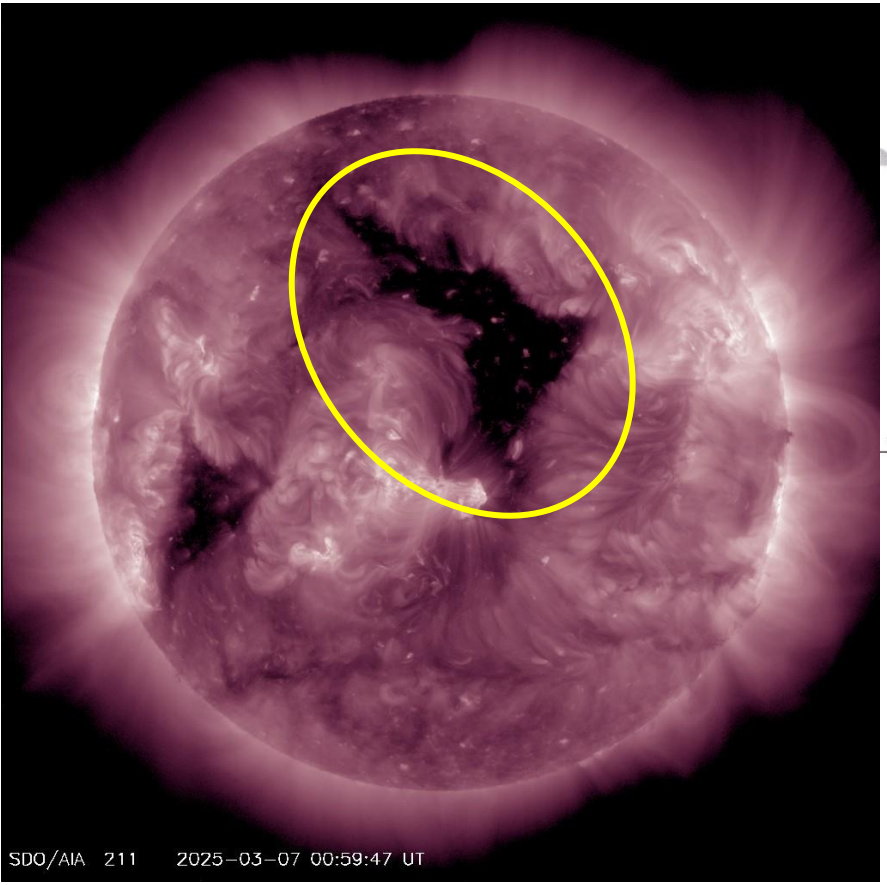
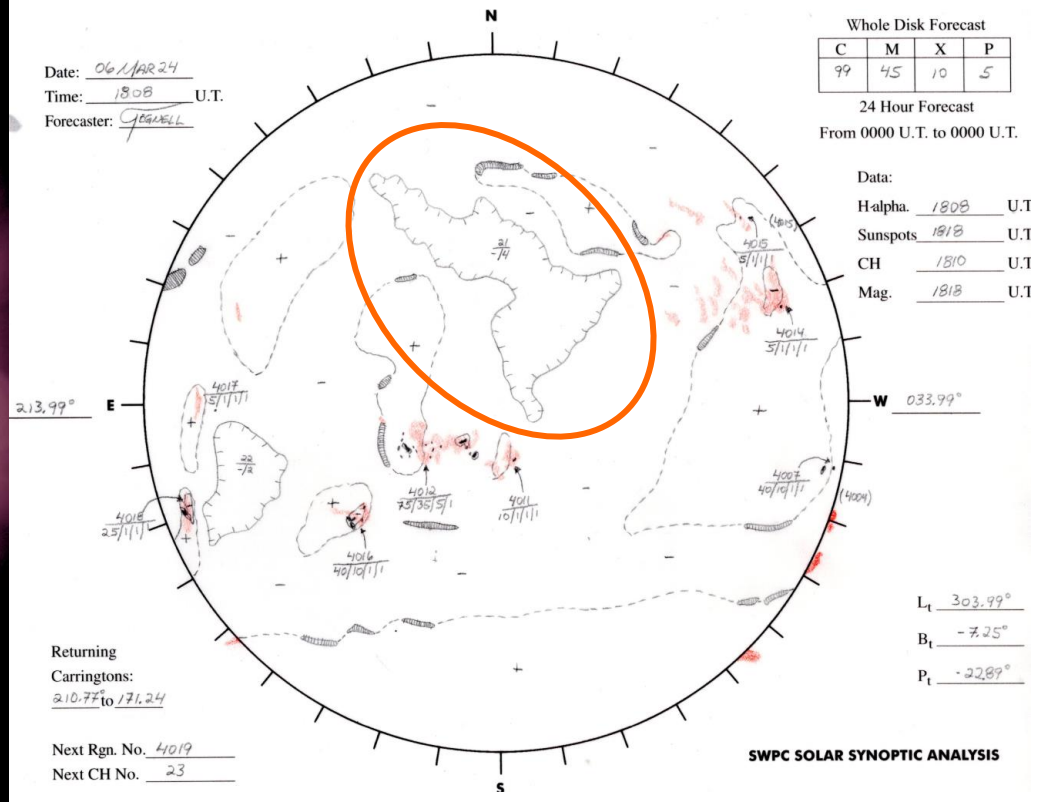
In the Declining Phase Coronal Holes Take Center Stage

SDO/AIA 211Å imagery



NOAA/SWPC Synoptic Chart



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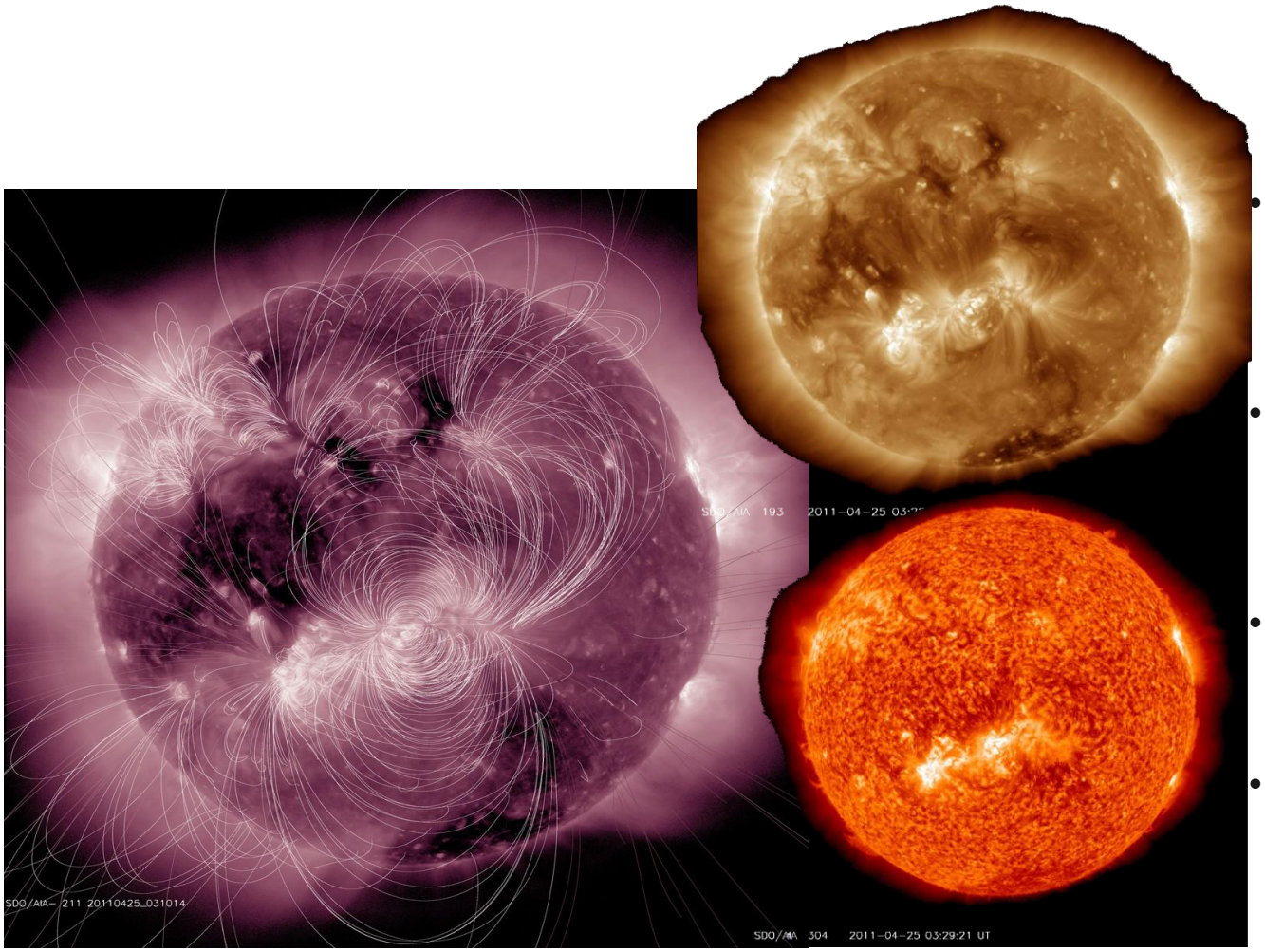
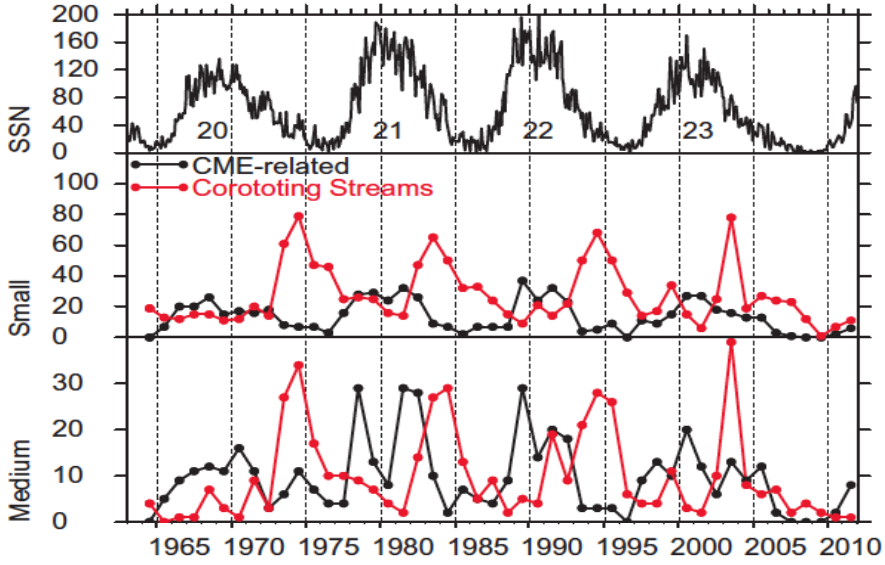
What Are Coronal Holes?

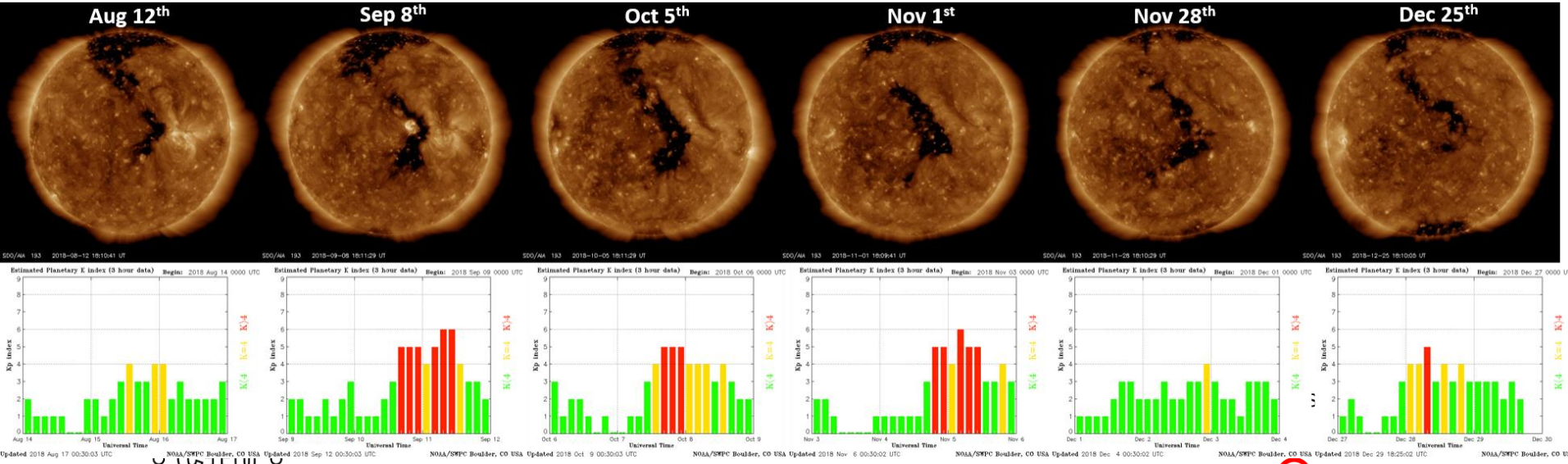


- Coronal holes appear as dark areas on the solar surface in EUV and X-ray imagery
- They have a lower density and temperature compared with the surrounding corona
- Coronal holes correspond to regions of open magnetic fields
- Visible best in lines with temperatures more than 105 K, e.g. 211A (pink) and 193A (bronze)

Coronal Holes Drive Recurrent Storms

- Geomagnetic storm activity always peaks during the declining phase
- This is when the incidence of stream interaction regions (SIRs/CIRs) observed at Earth increases dramatically
- CIRs are due to high-speed solar wind streams from “persistent” coronal holes
- This cycle will have faster high-speed streams than Cycle 24





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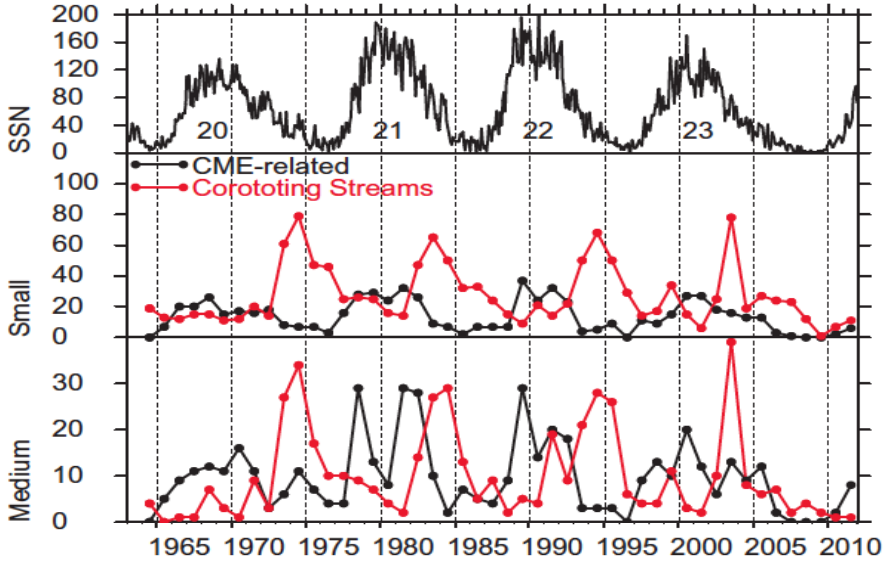
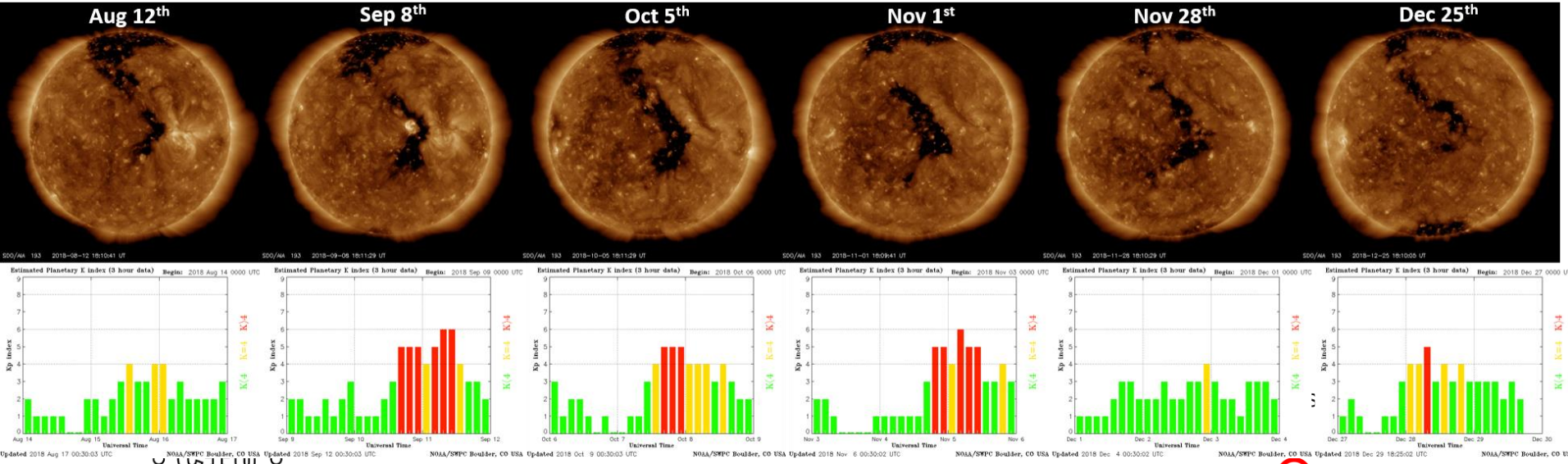
Coronal Holes Drive Recurrent Storms

- The declining phase is unlike any other period in the solar cycle
- Space weather becomes more predictable
- Every 27 days old patterns return
- For radio propagation, the trick is knowing *what kind* of fast wind is streaming from these “persistent” coronal holes
- This depends upon the season





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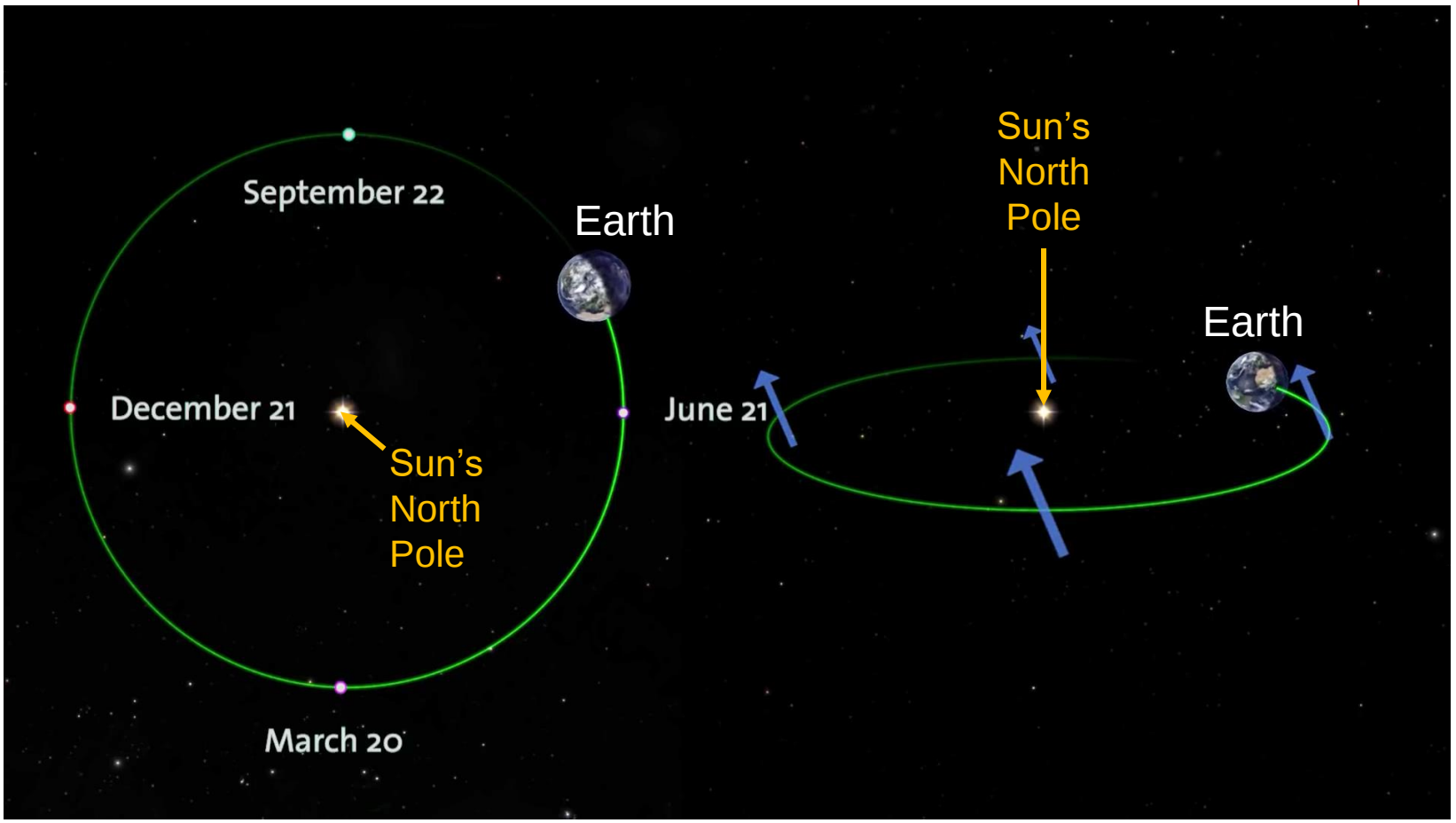
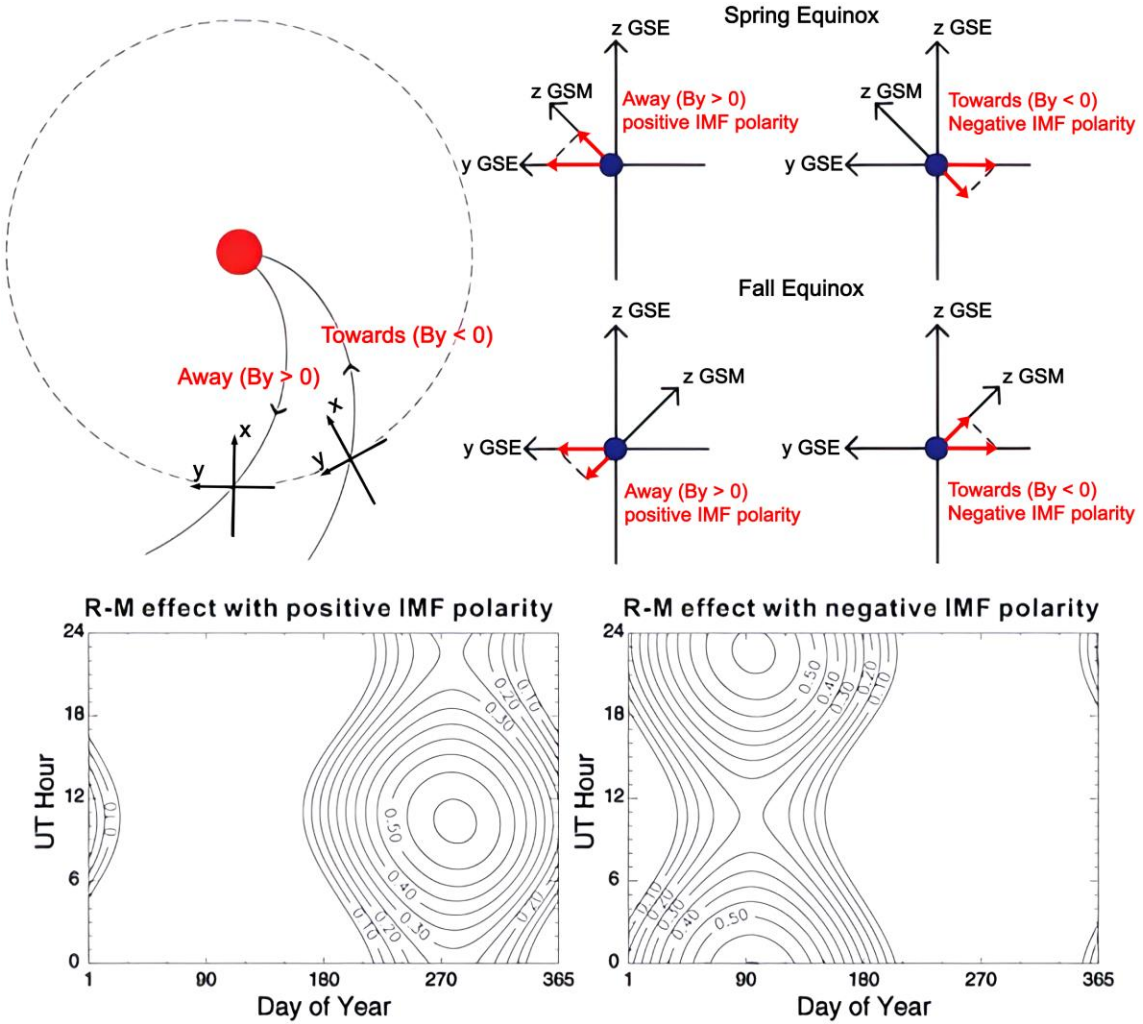
Space Weather at Earth Has Seasons

During the declining phase of the solar cycle, we can take advantage of these seasons to predict quiet and stormy times



Russell-McPherron Effect

We shall explain this well-known and often misinterpreted diagram



Zhao and Zong, JGR, 2012

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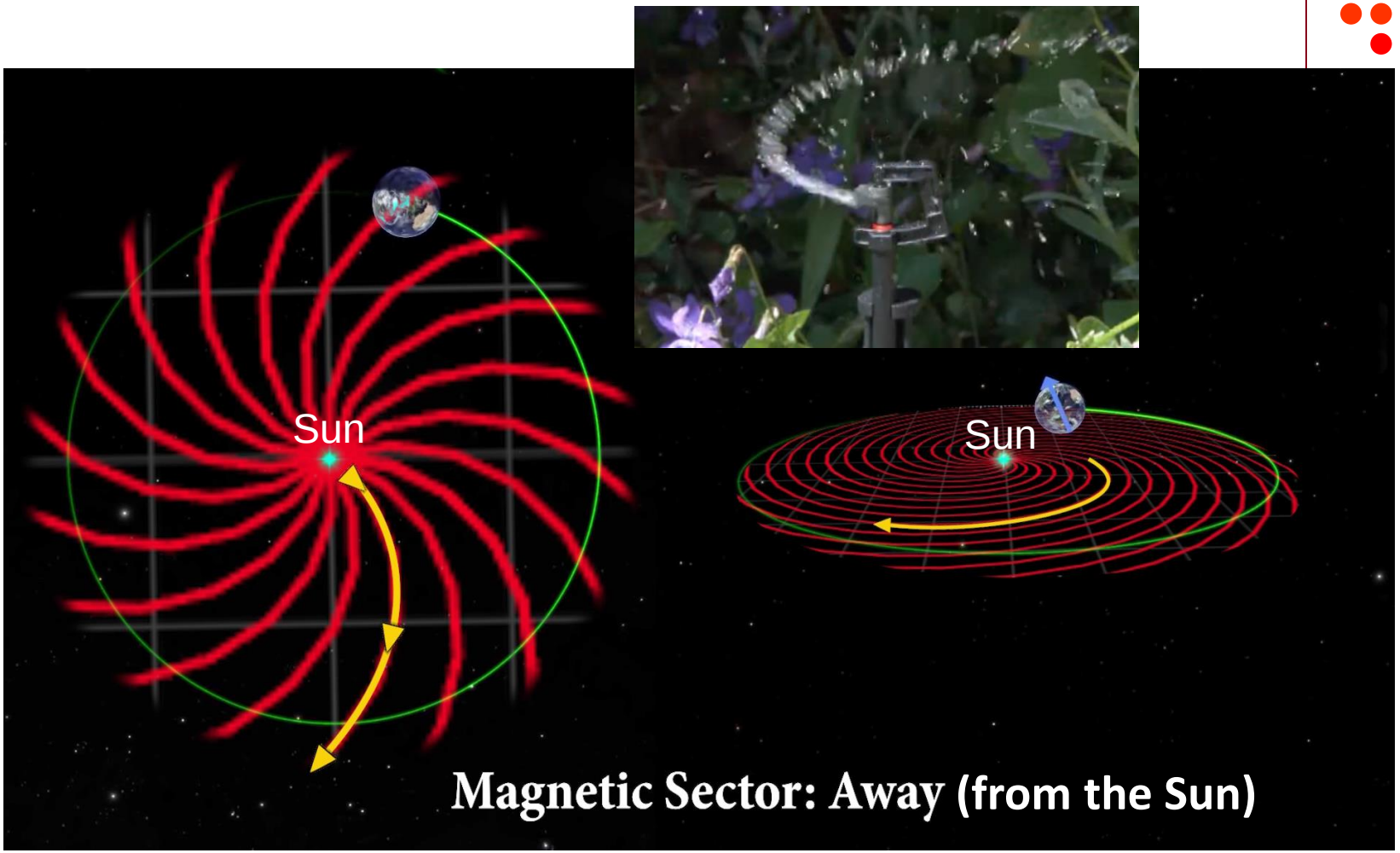
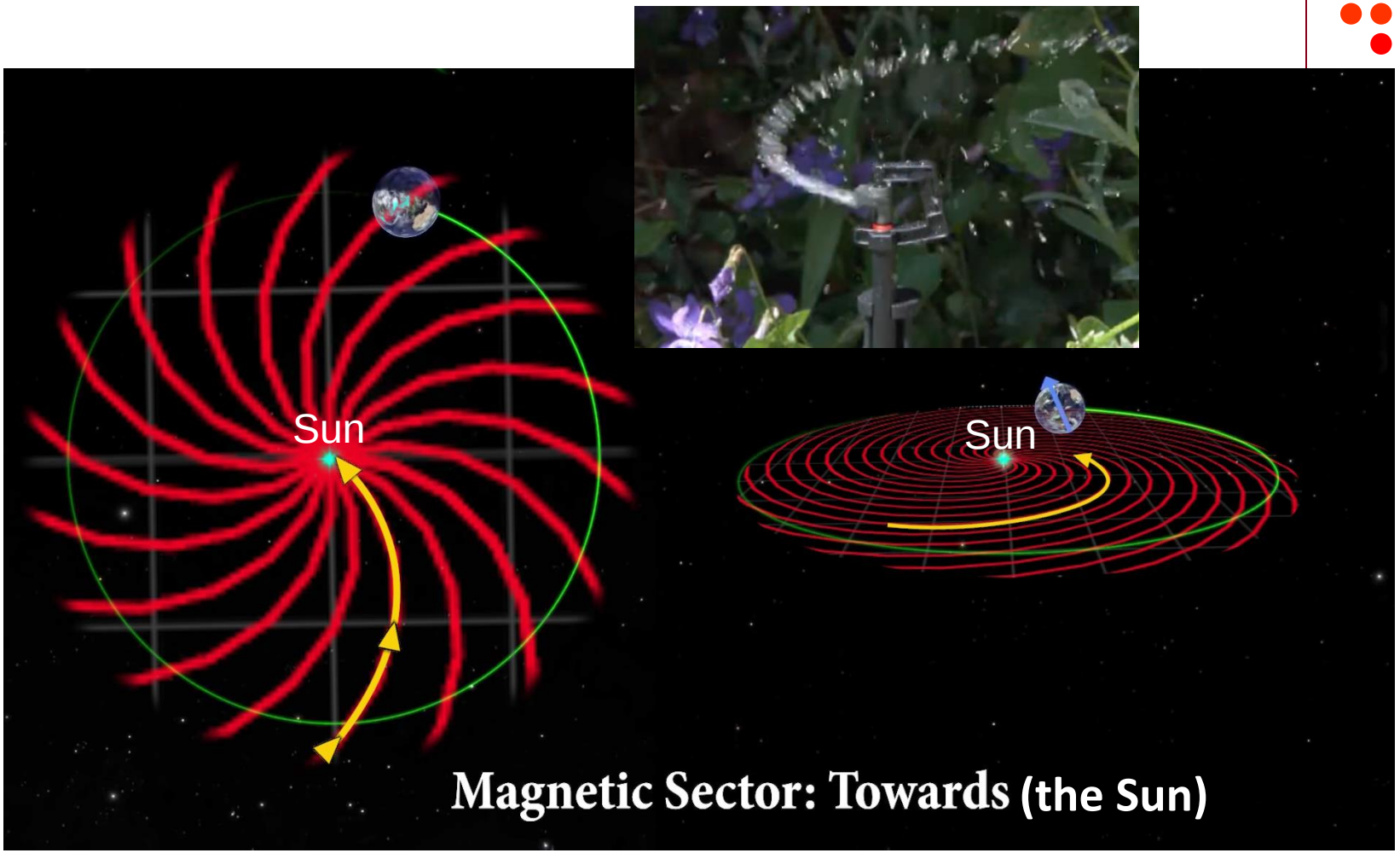
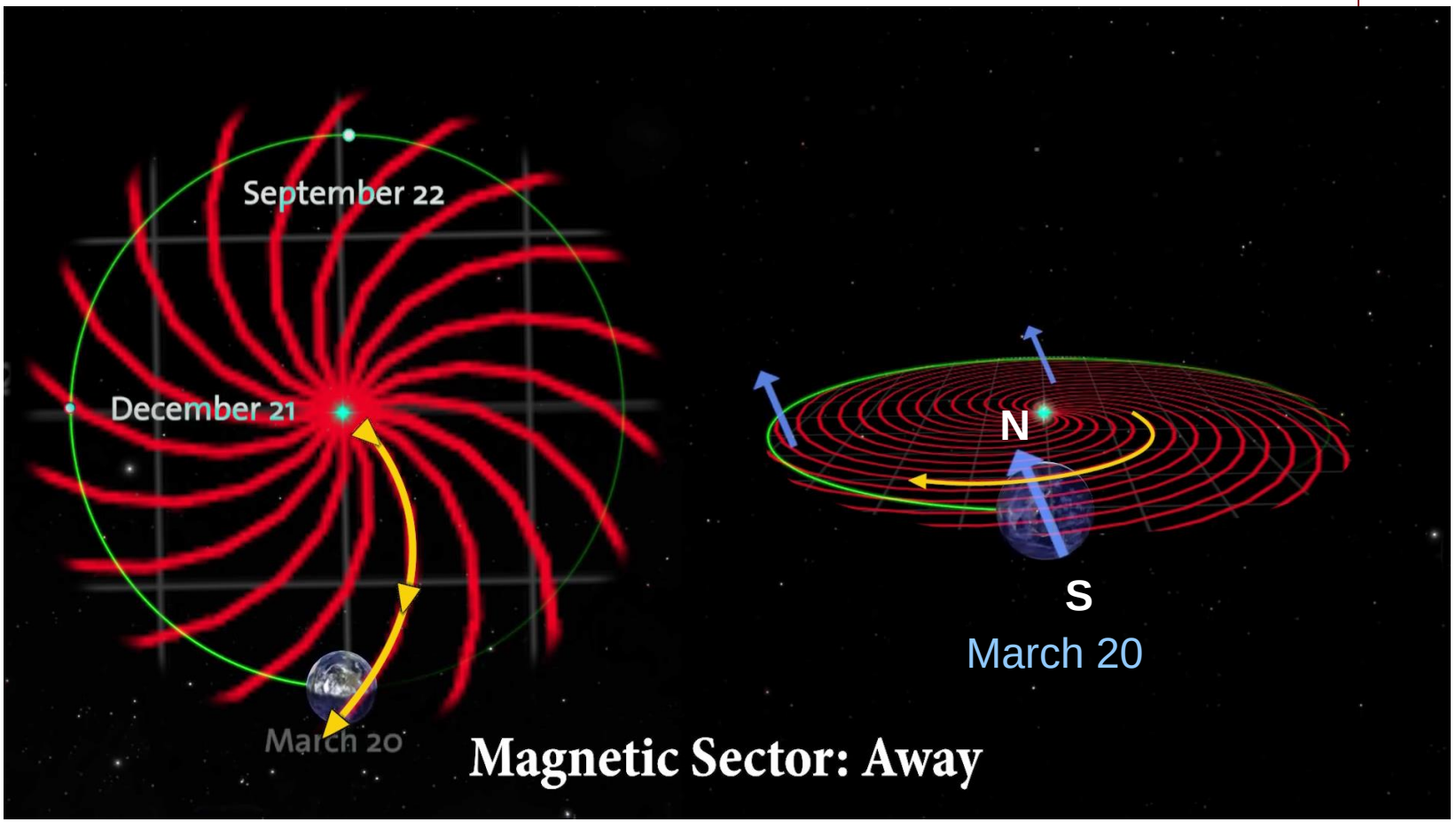
The Sun is a Rotating Sprinkler



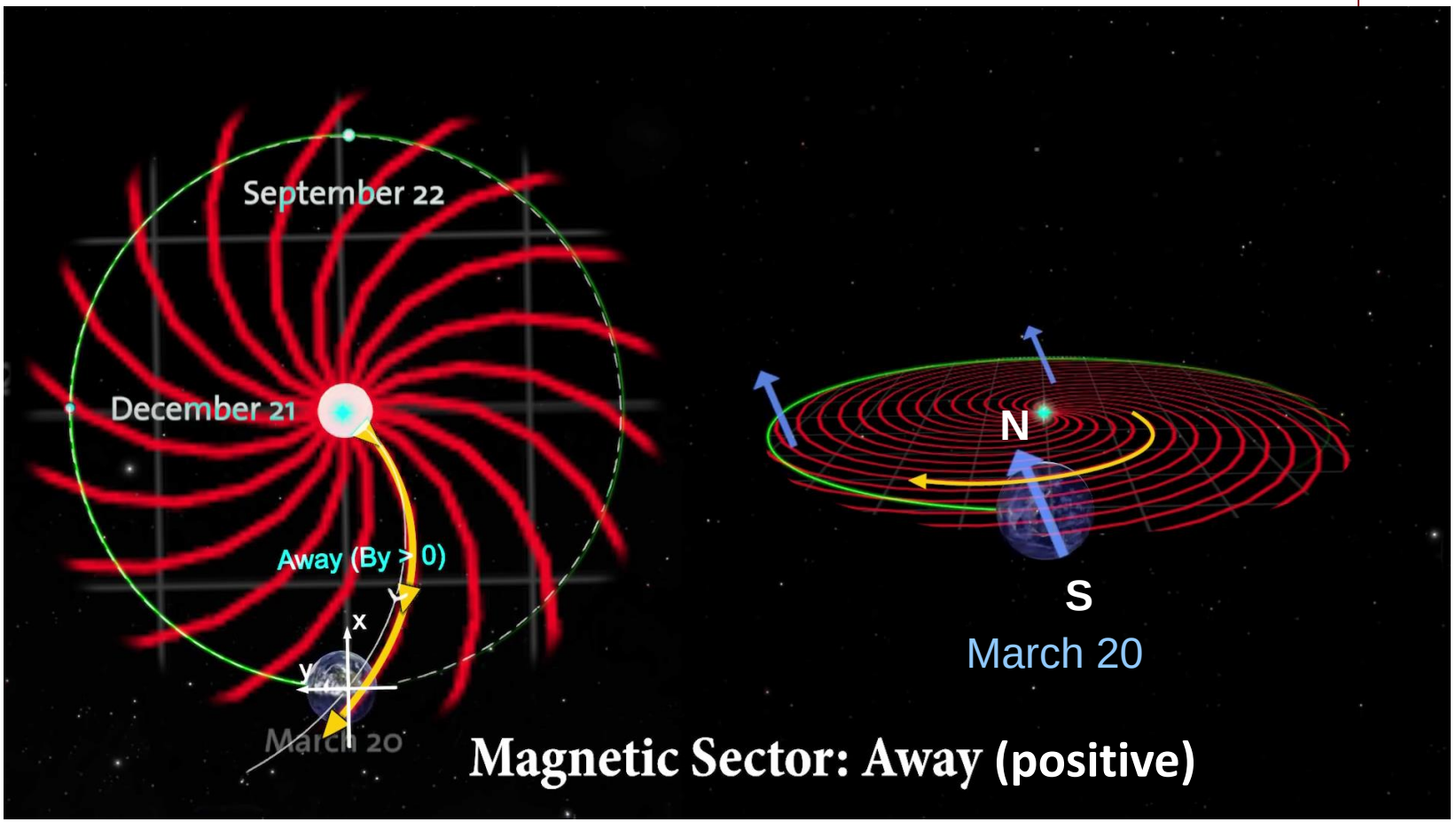
The Sun is a Rotating Sprinkler



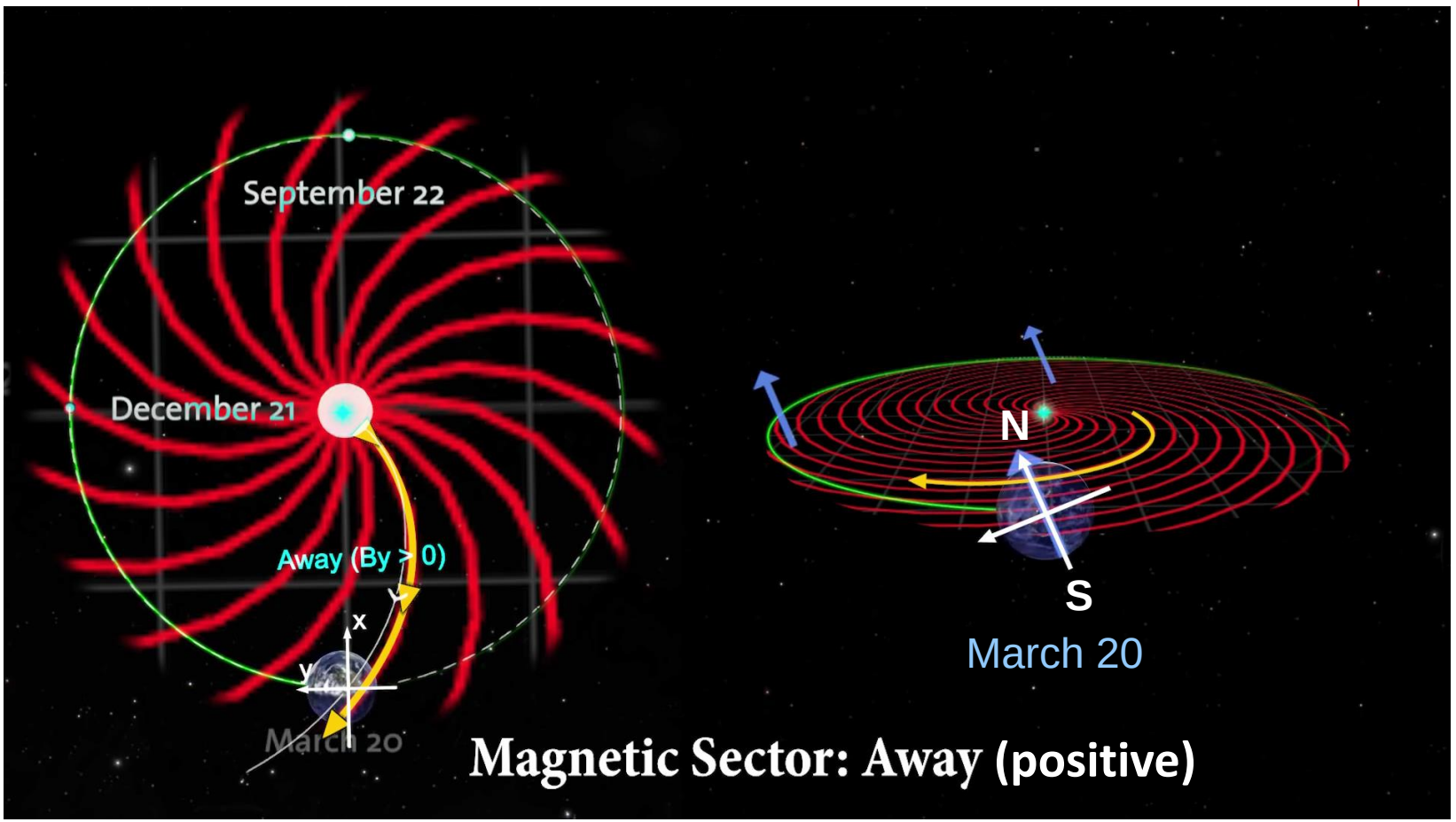
Spring Equinox Effects



Spring Equinox Effects



Spring Equinox Effects



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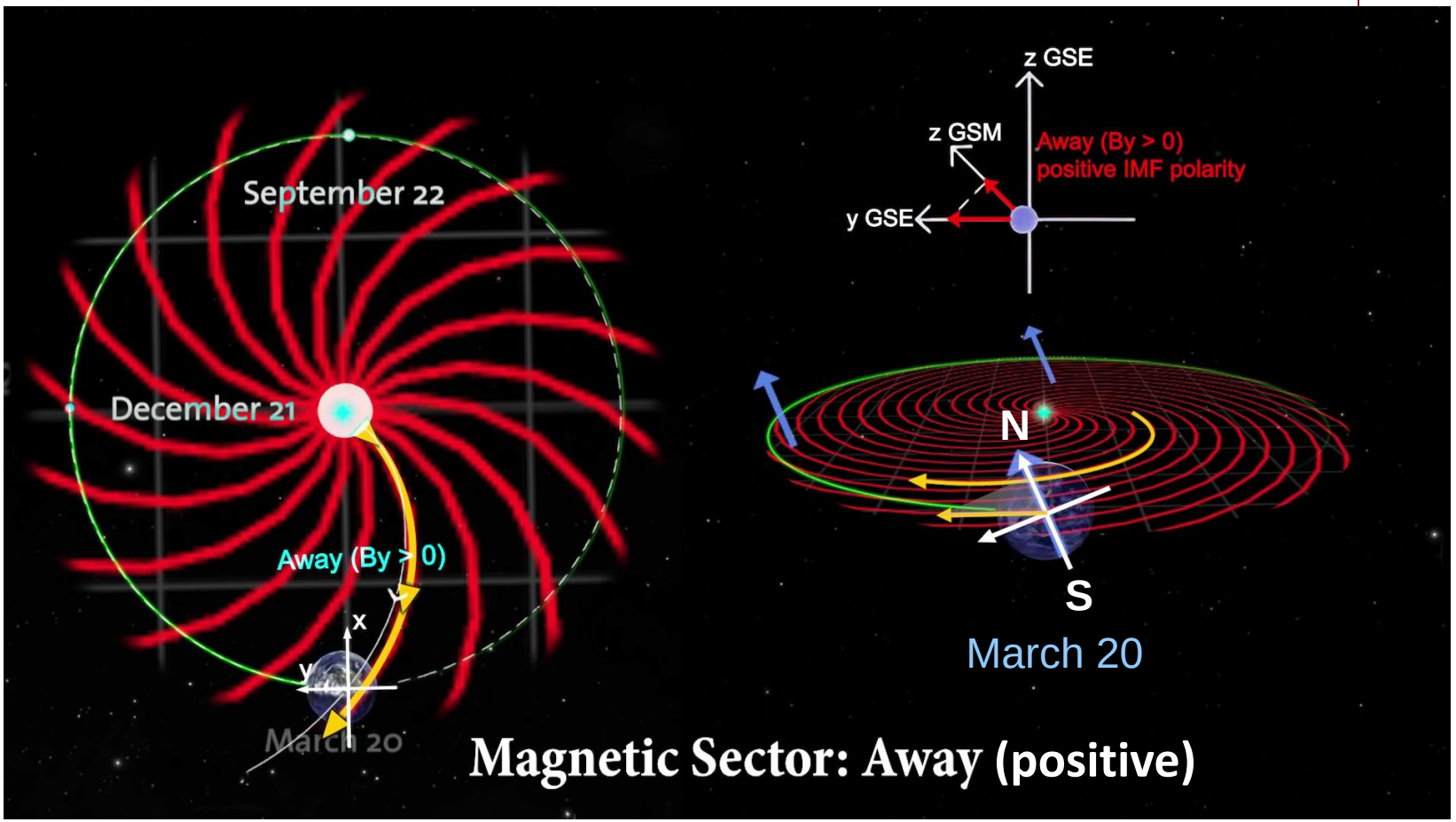
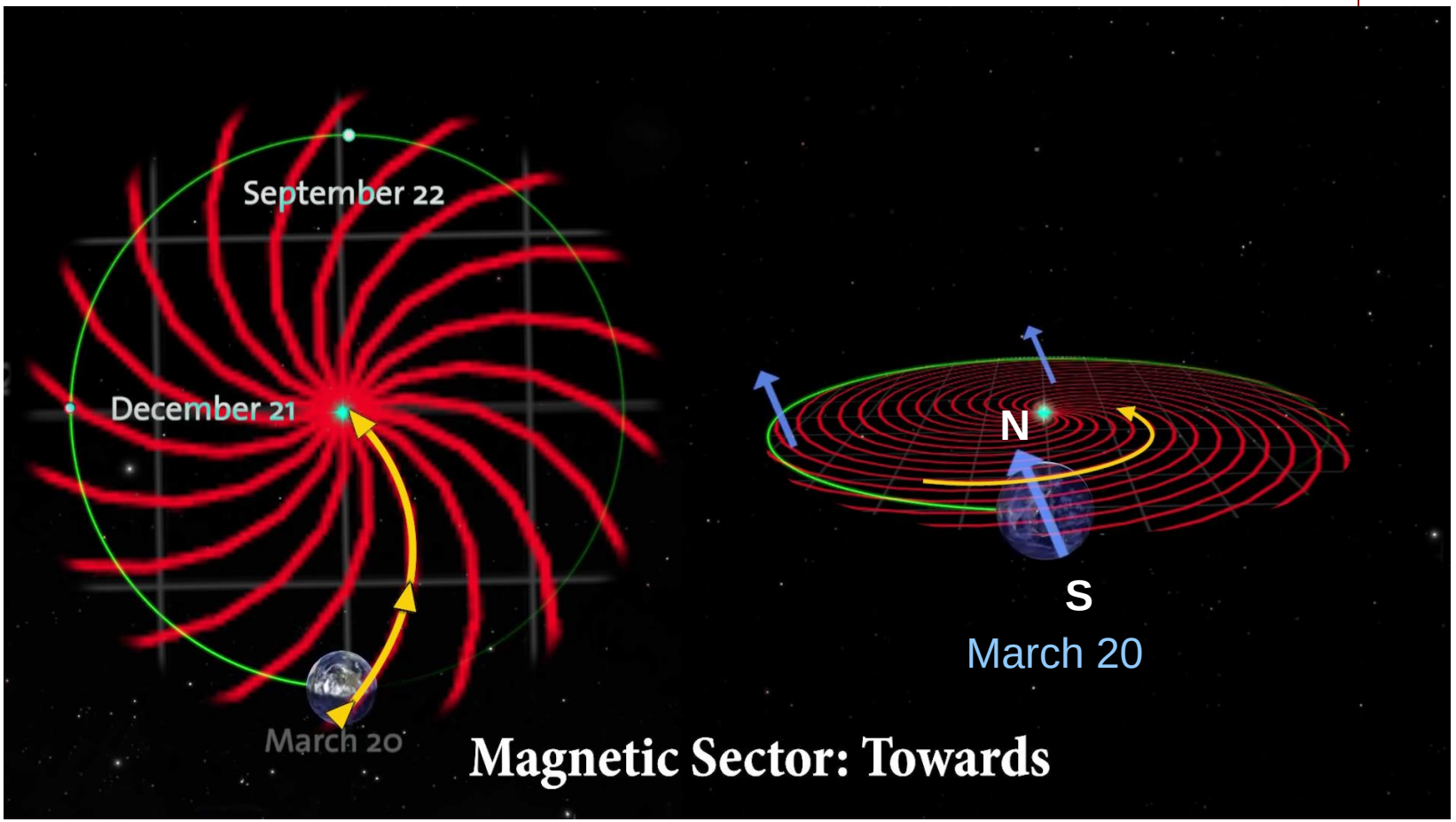
Spring Equinox Effects



Spring Equinox Effects



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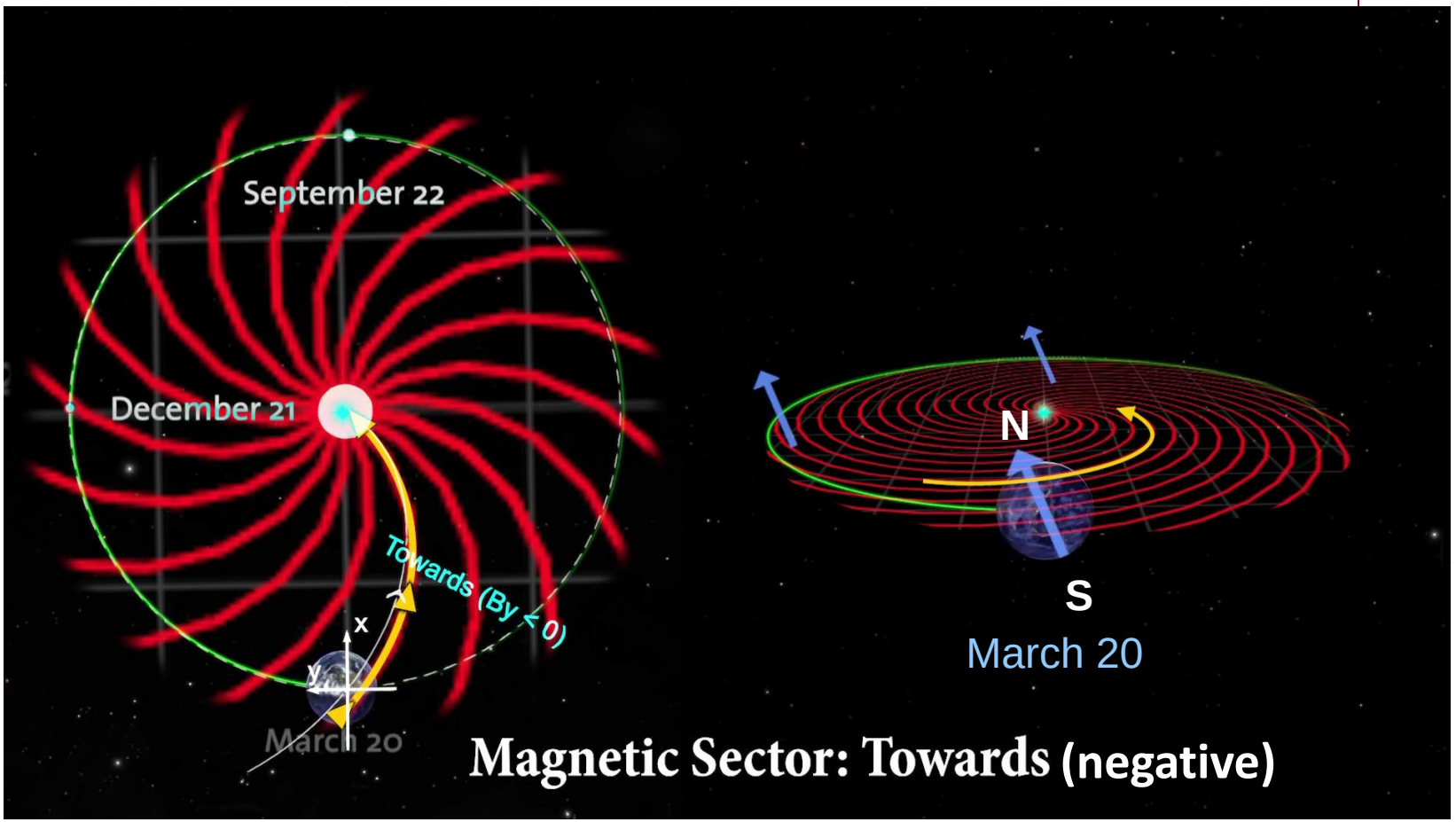

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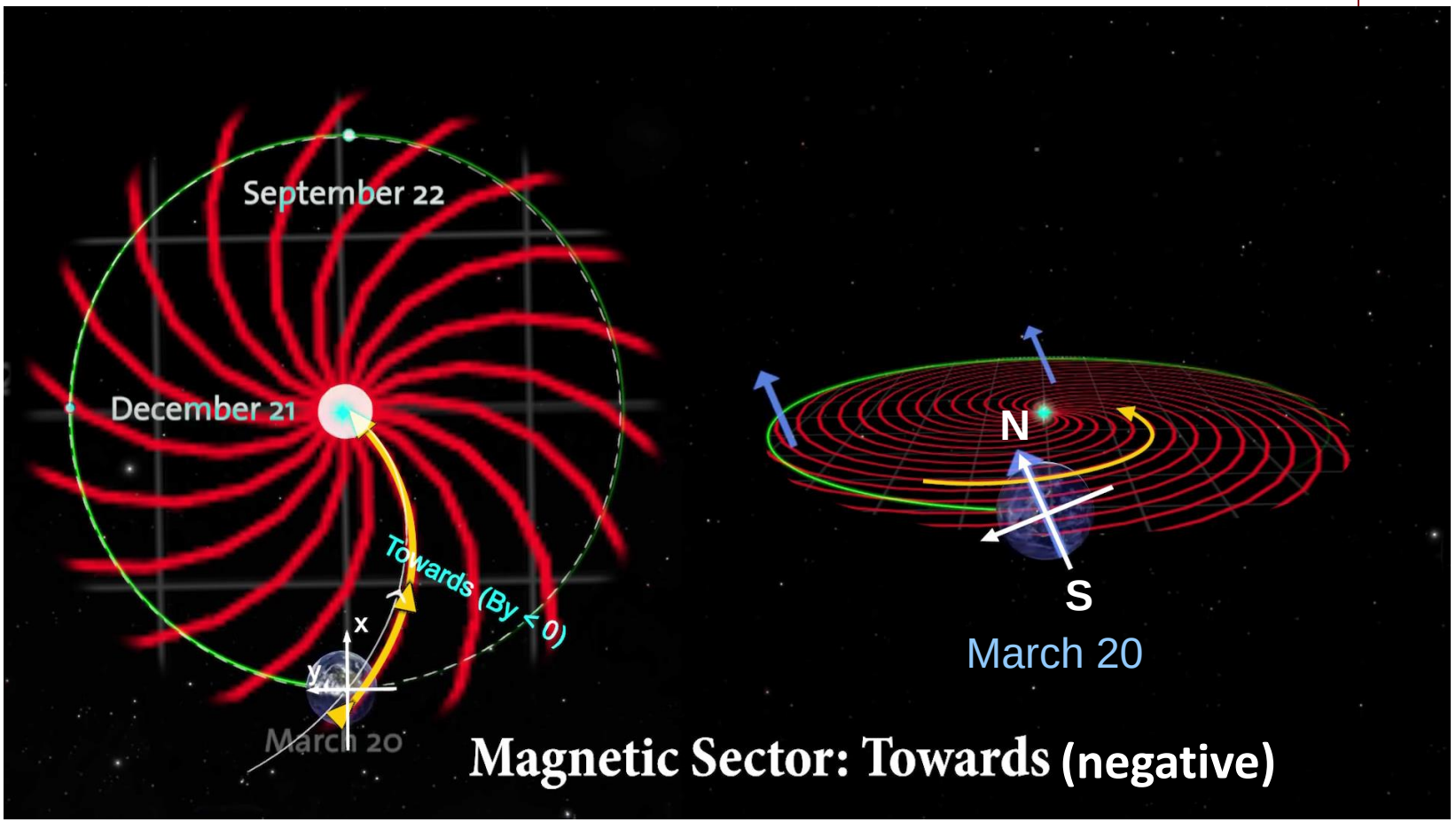
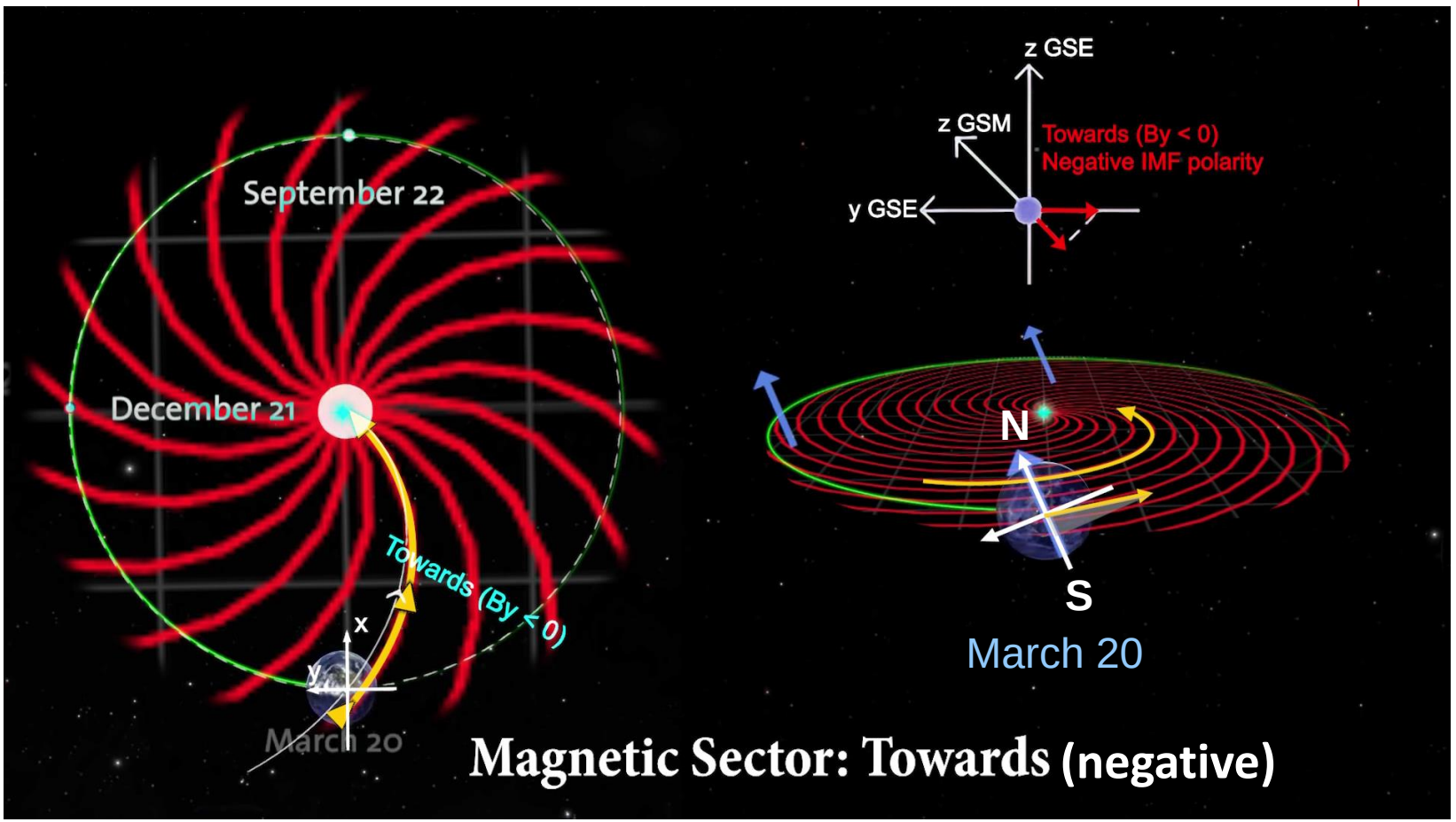
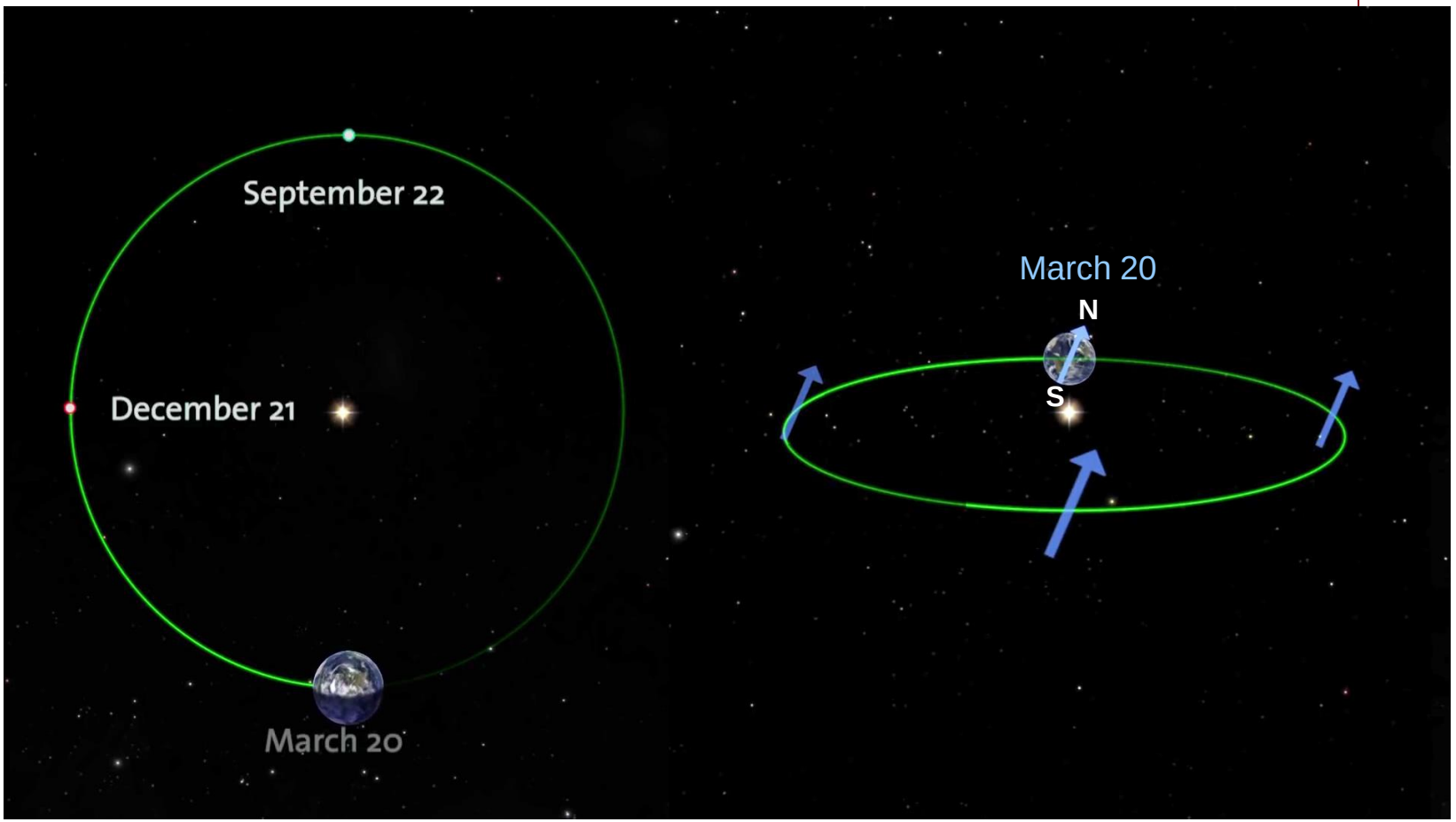


Spring Equinox Effects



From Spring to Autumn Equinox

Switching perspectives to the location of the autumn equinox shows the tilt of the Earth's axis has changed relative to Earth's orbit



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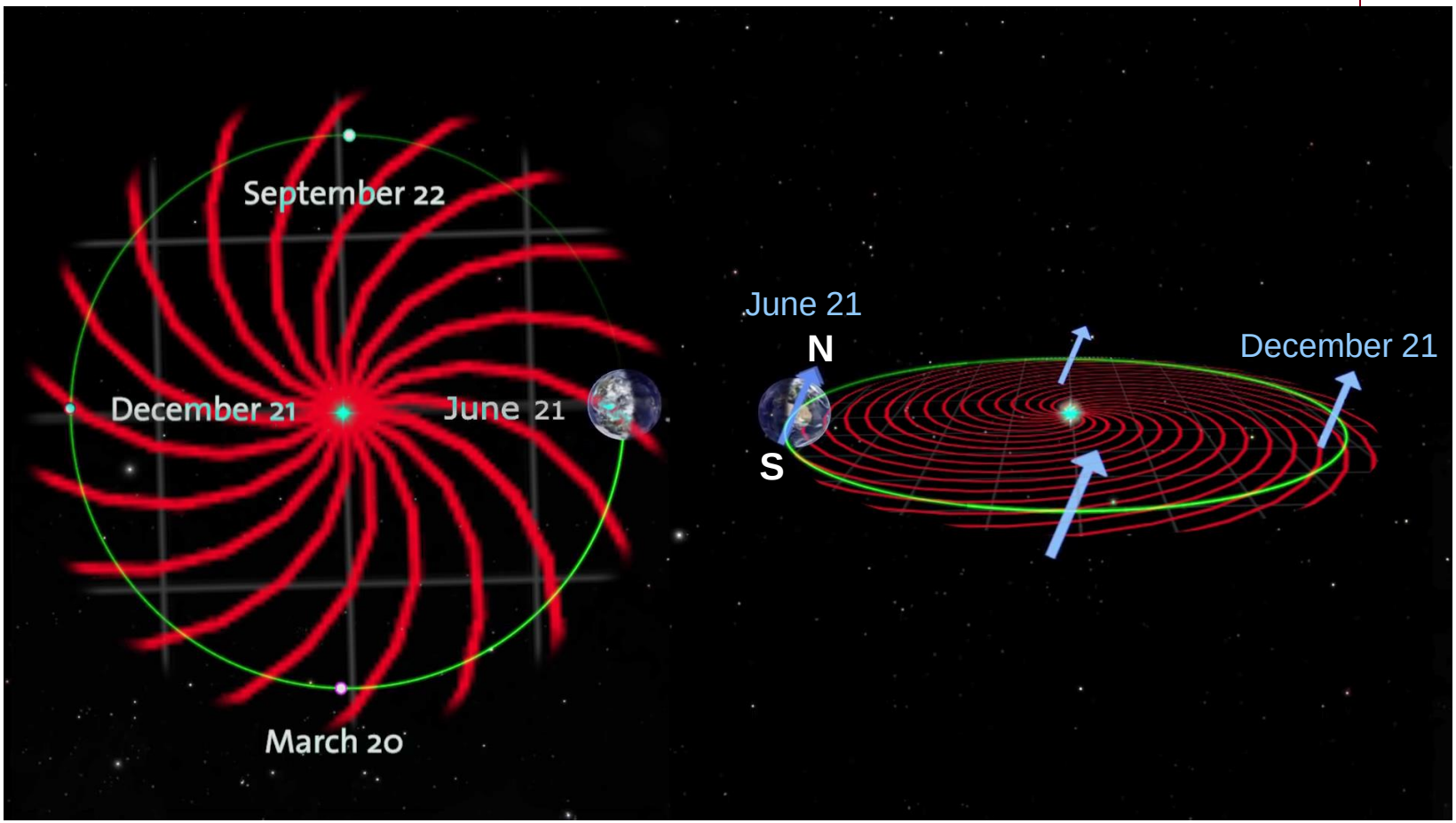
Passing Through the Solstices

During the solstices the Earth's axis tilts along the Earth-Sun line so the Russell-McPherron effect minimizes near June 21 and December 21



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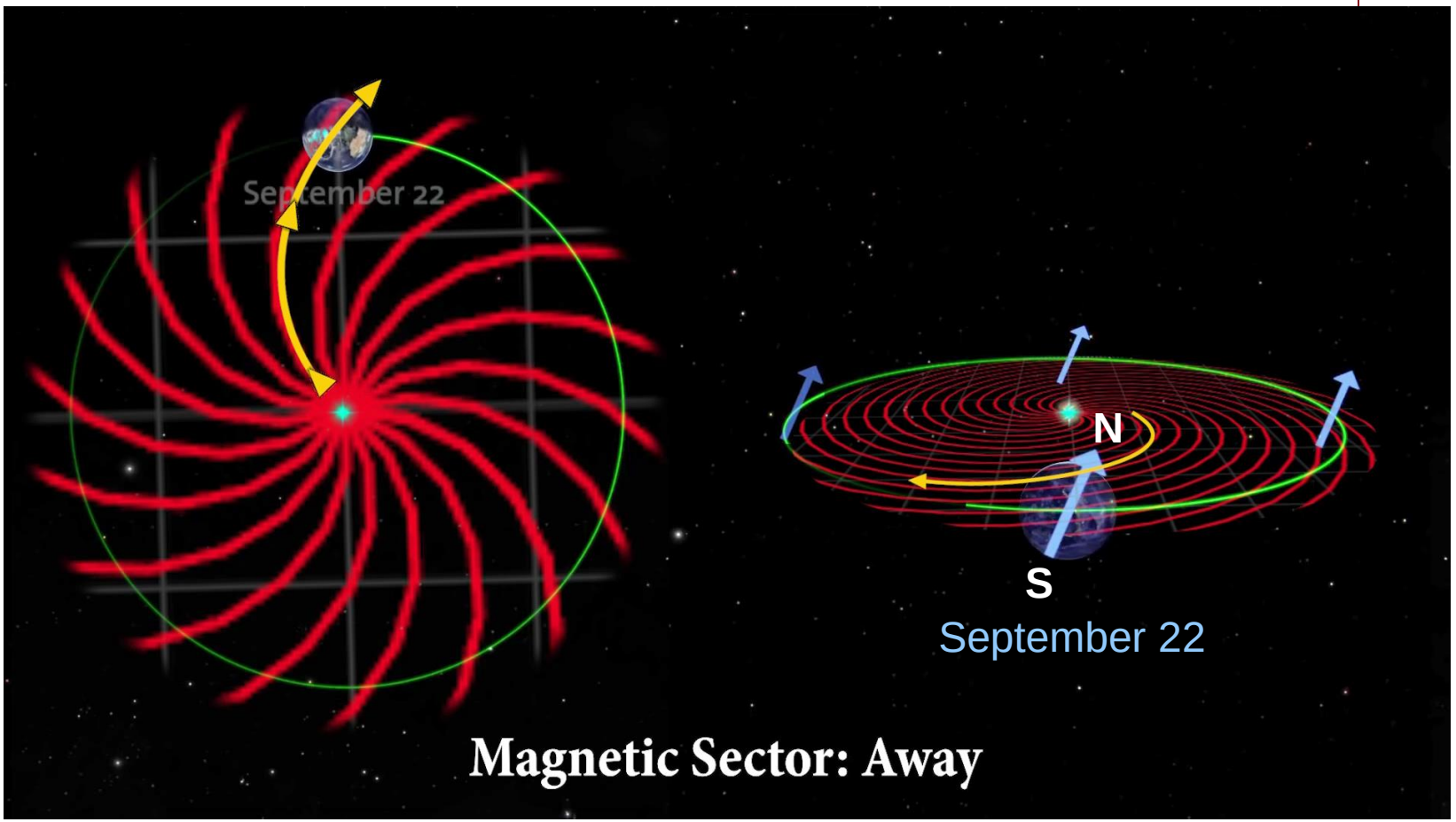
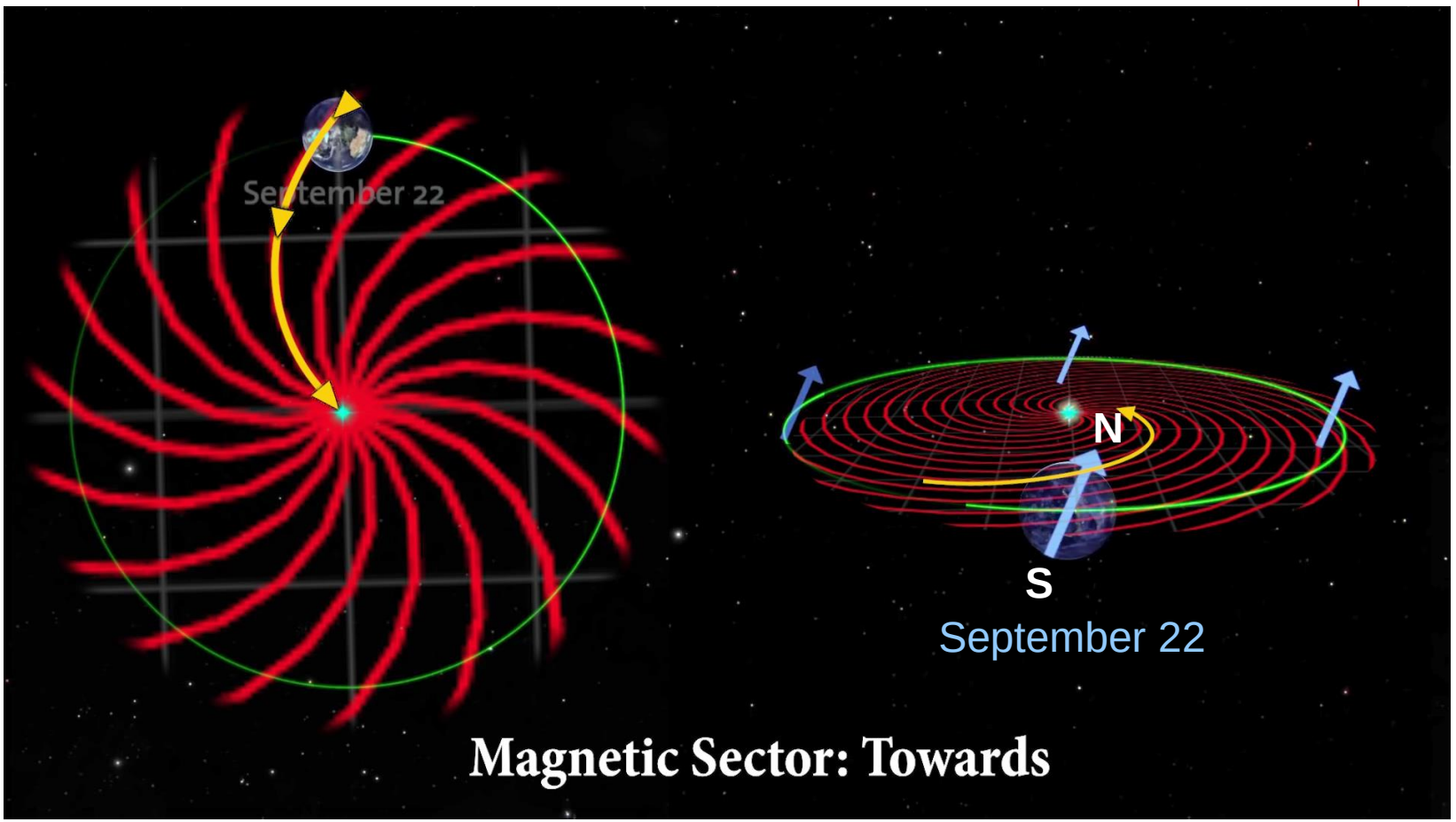
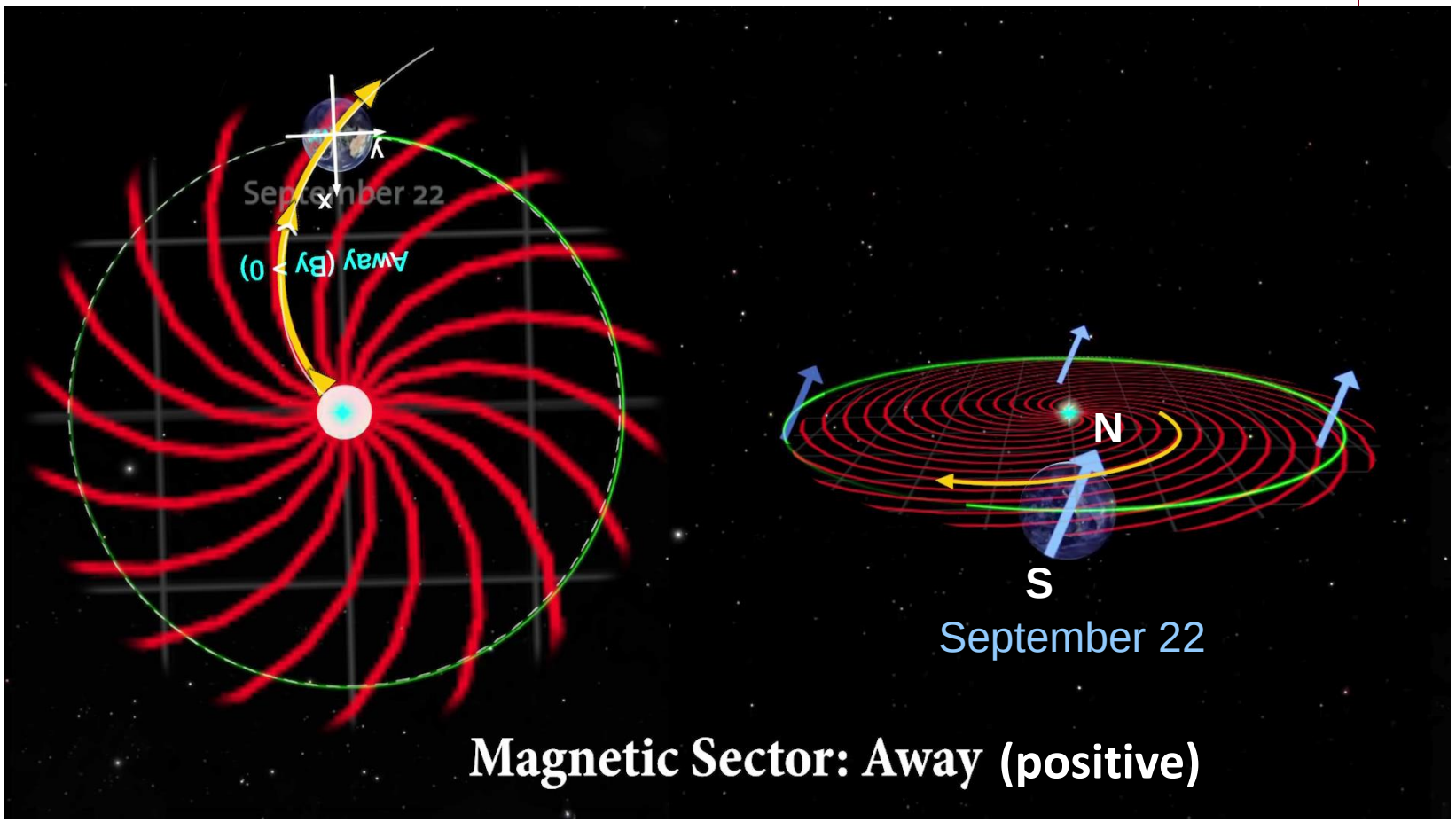
Autumn Equinox Effects



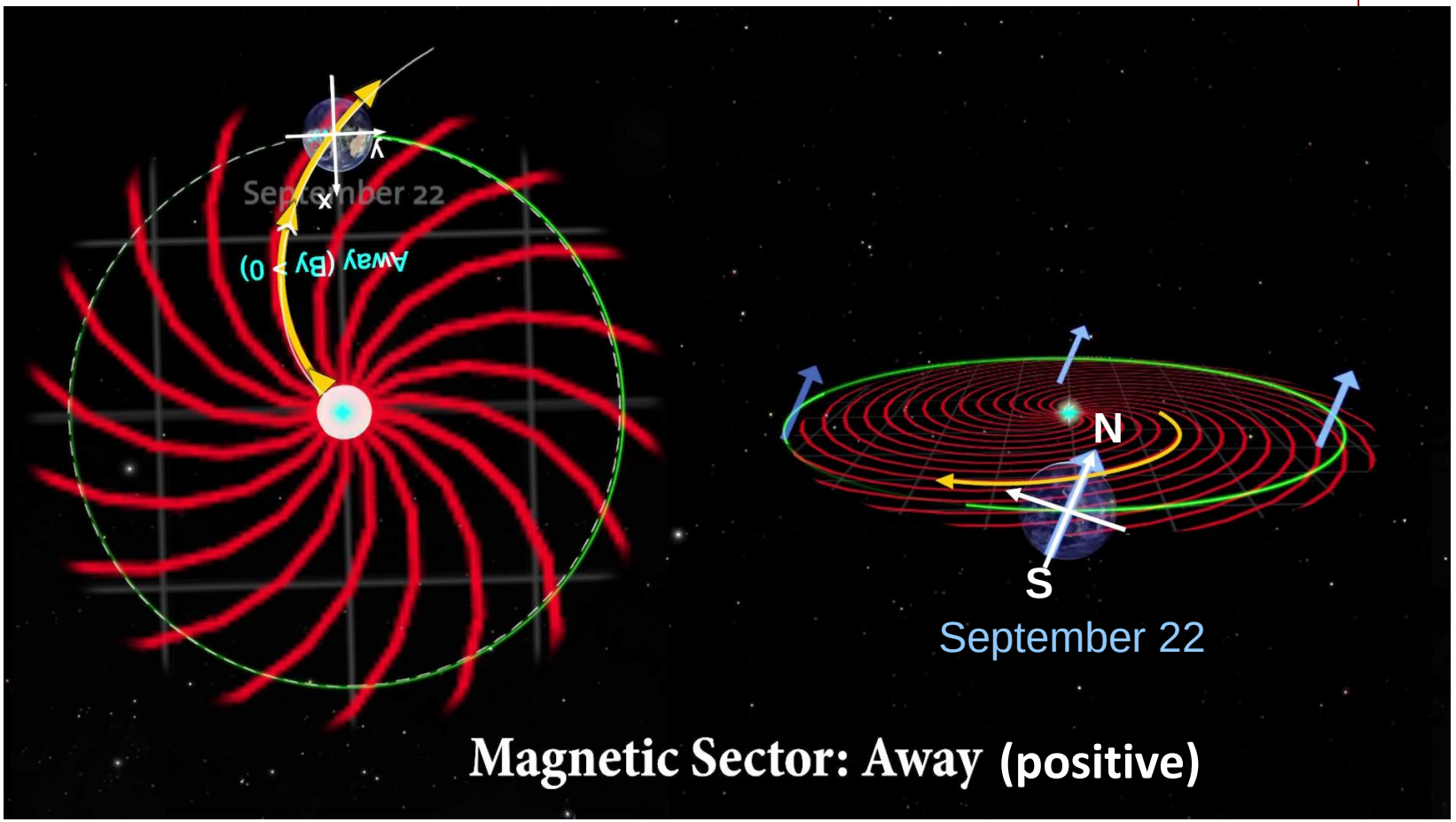
Autumn Equinox Effects



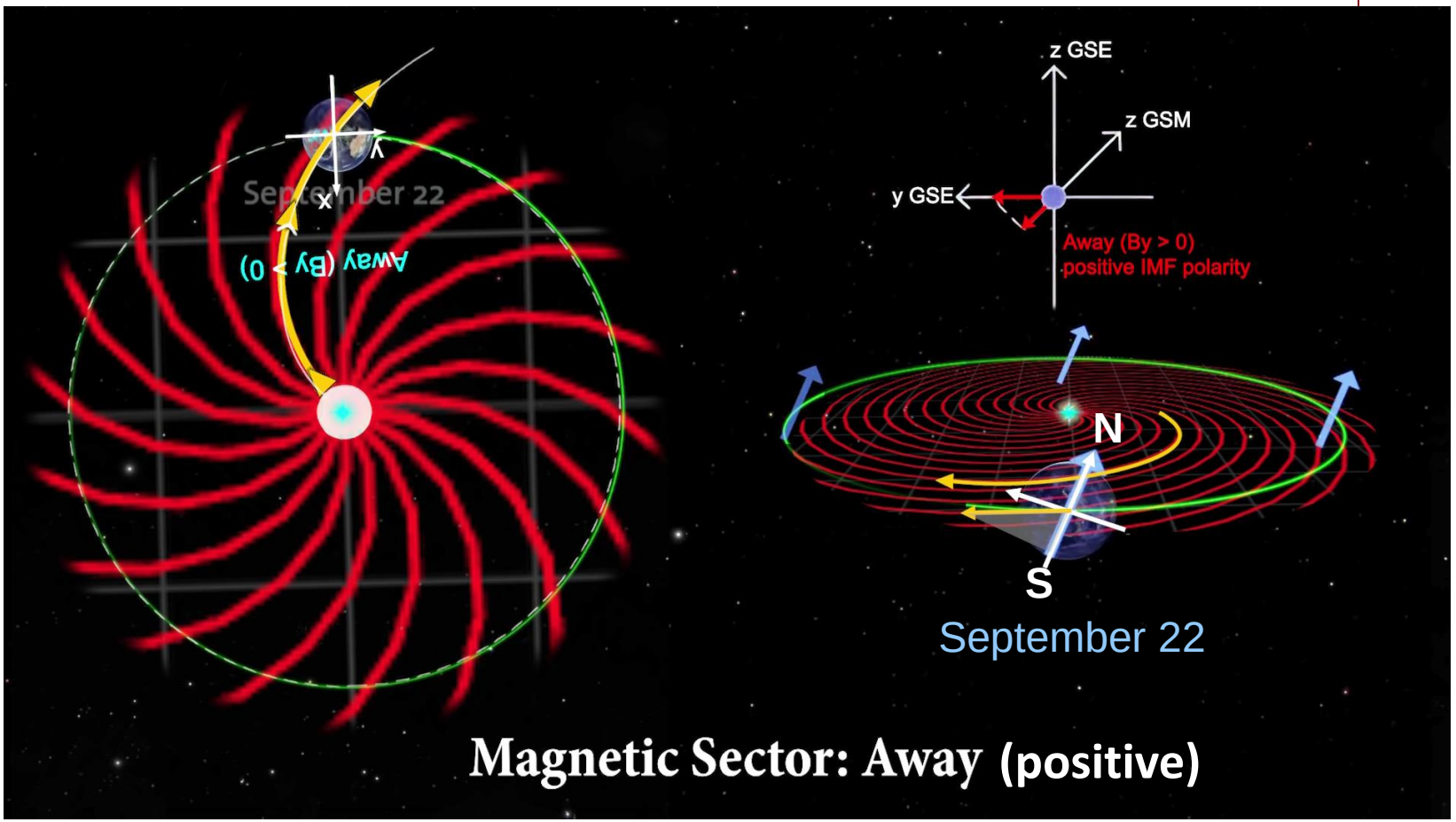
Autumn Equinox Effects



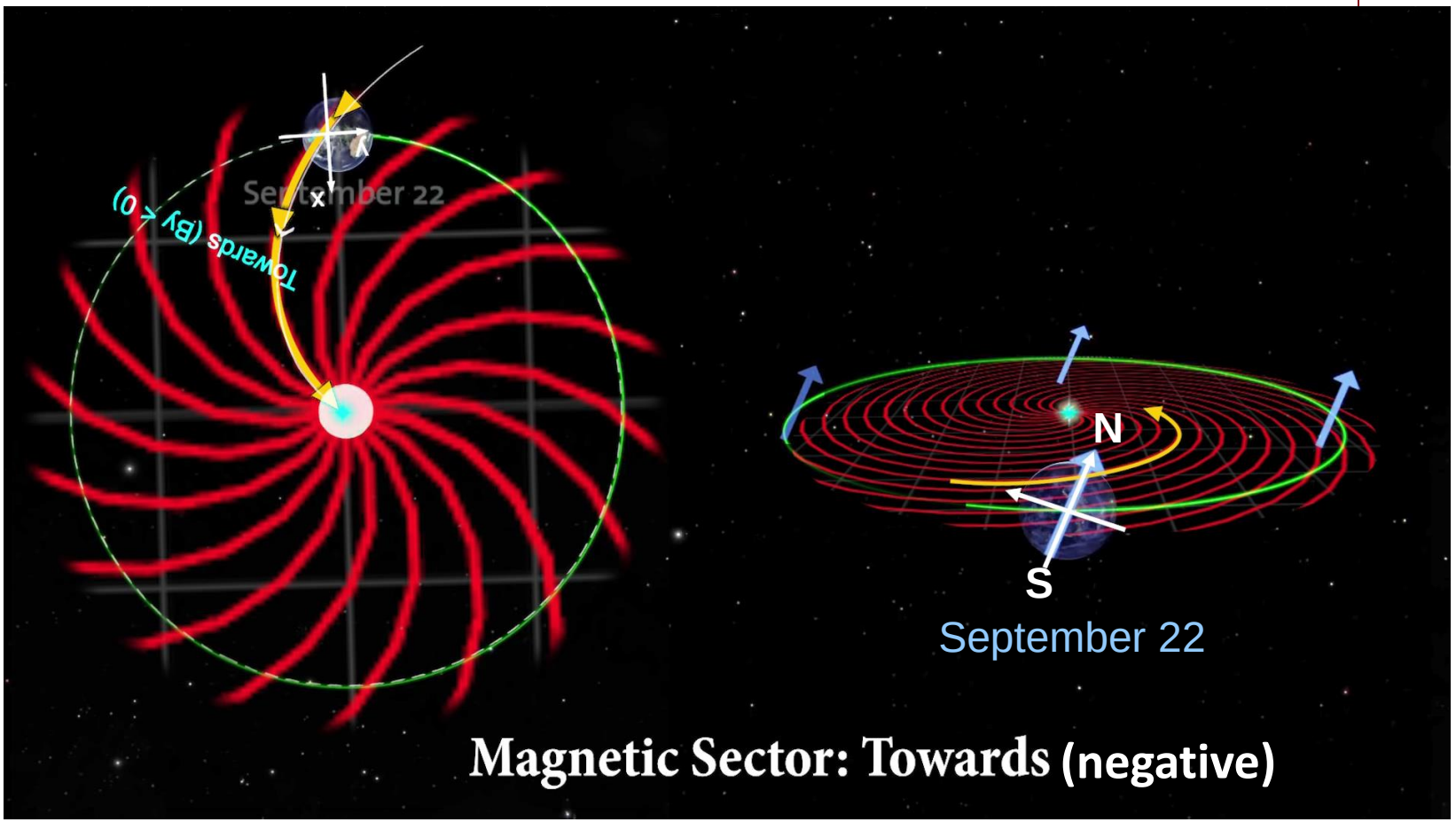
Autumn Equinox Effects



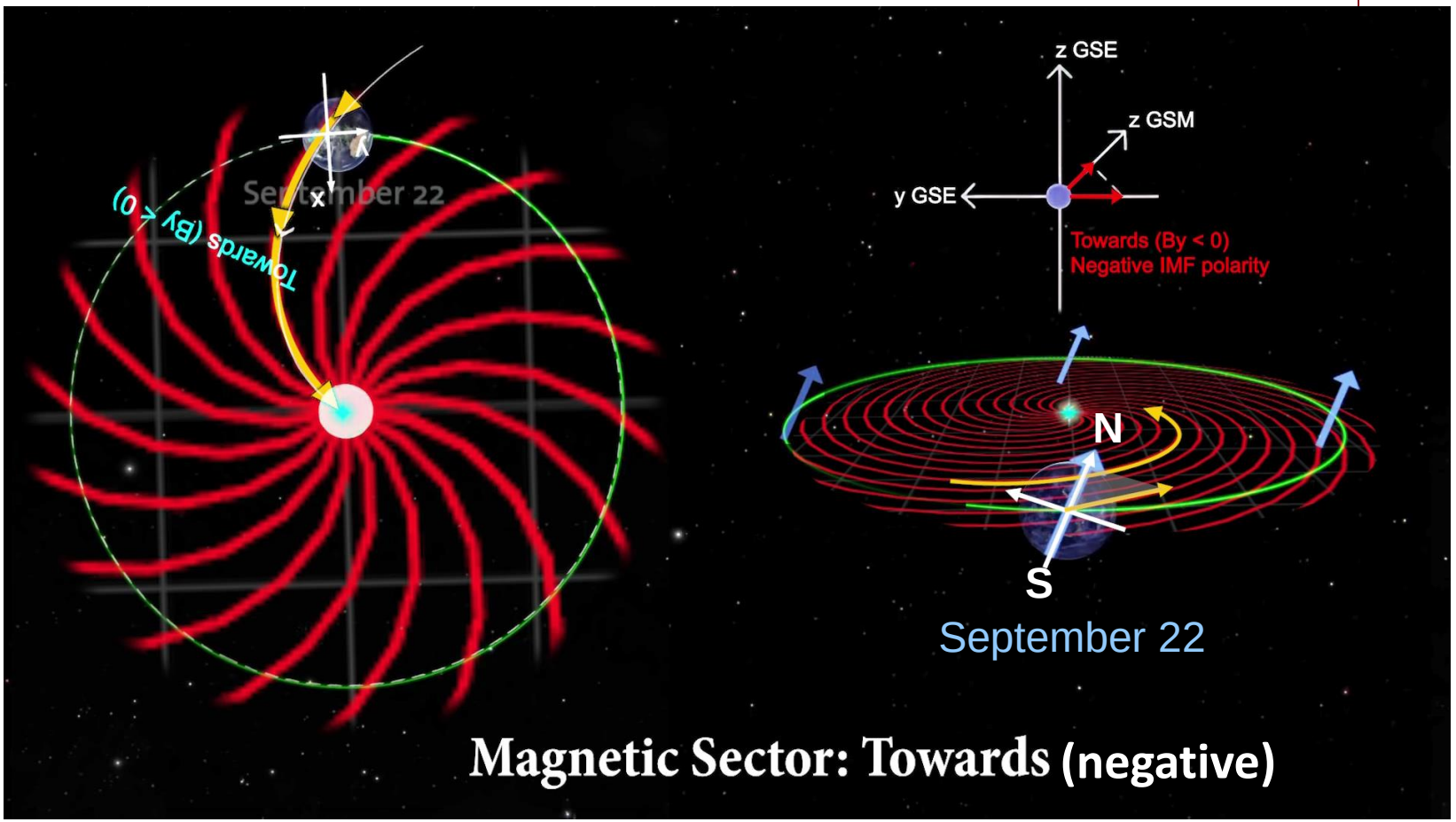
Autumn Equinox Effects



Autumn Equinox Effects

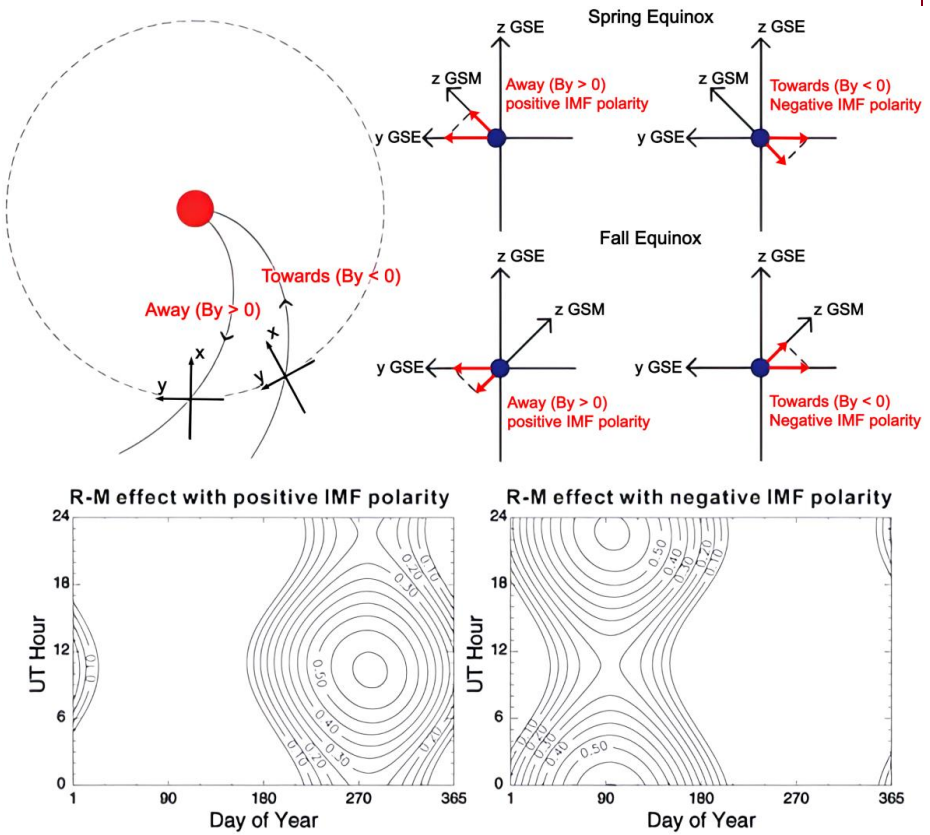


Autumn Equinox Effects



Russell-McPherron Effect

- Utilize this effect to know when northward field is coming
- Northward field creates calm geomagnetic conditions, which quiets the ionosphere
- This facilitates radio propagation
- In other words, some coronal holes are actually useful!



Spring equinox favors negative (towards) sectors for storming
Autumn equinox favors positive (away) sectors for storming

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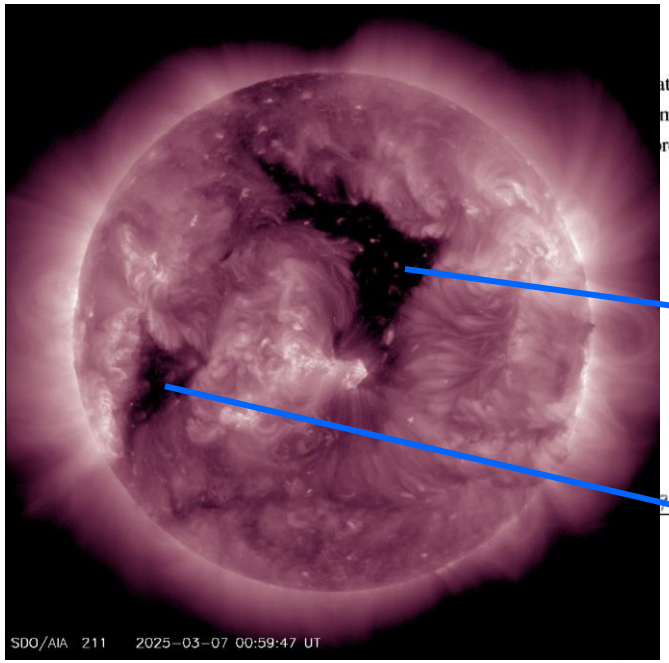
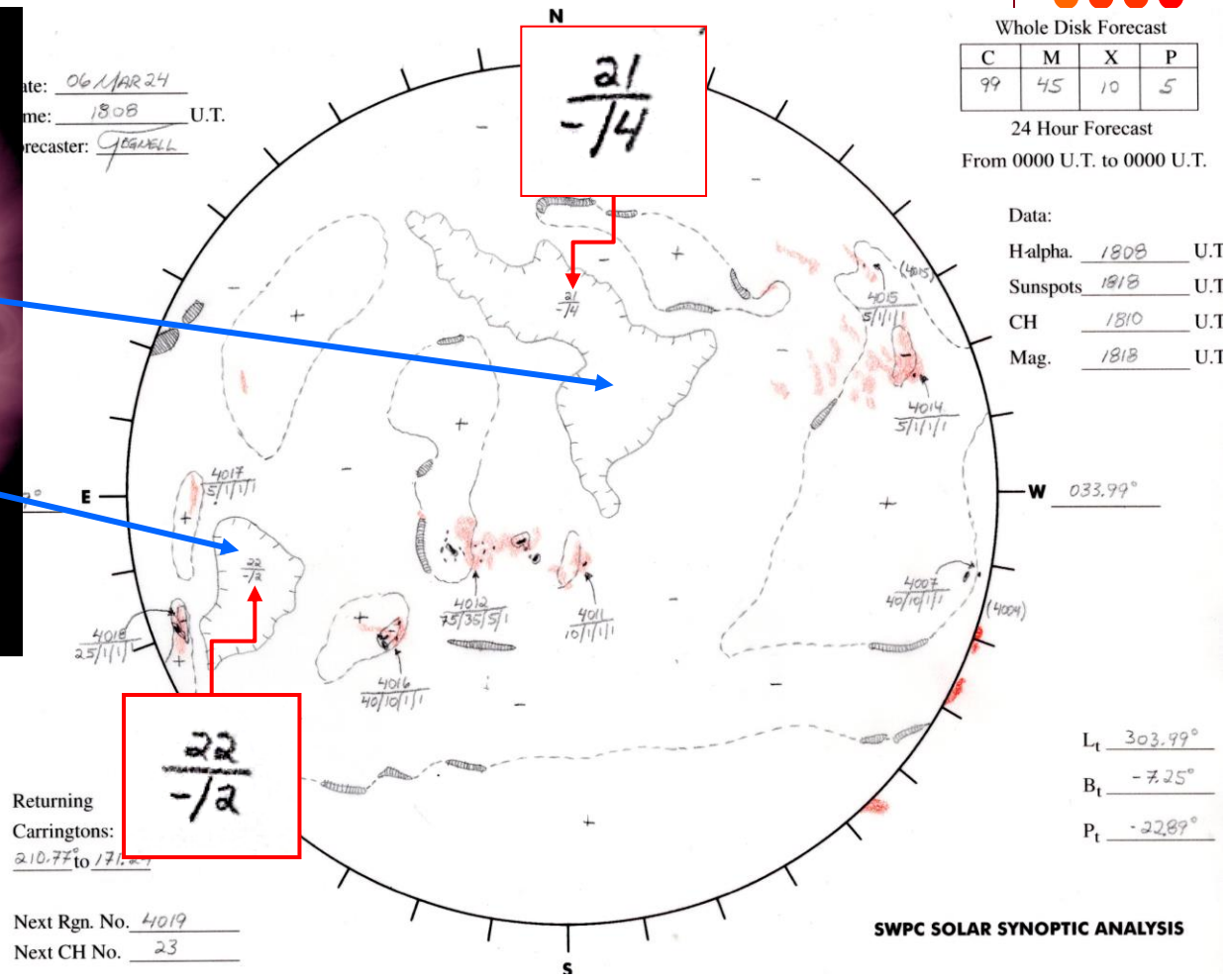
Coronal Hole Polarities Deciphered





Spring→Negative

Autumn→Positive

S.N.A.P.

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Summary

- We are in the declining phase of Solar Cycle 25, which has been “average” in terms of overall solar activity
- Expect F10.7cm radio flux to drop below 100 in mid-to-late 2027 (Lynker-Space predictions as of late 2024)
- Geomagnetic activity peaks in this phase due to a combination of Earth-directed solar storm eruptions & SIRs/CIRs
- Coronal holes are persistent and more predictable during this phase
- Cycle 25 coronal holes are stronger than Cycle 24, creating faster solar wind streams and thus larger extremes of quiet and stormy space weather affecting radio propagation
- The “Russell-McPherron Effect” predicts when these periods will occur and thus can be used to inform propagation forecasts
- Remember it’s a “S.N.A.P” to know when stormy weather is expected