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Cosmic Rays from the Termination Shock to the Heliopause: The Role of the Heliospheric Current Sheet

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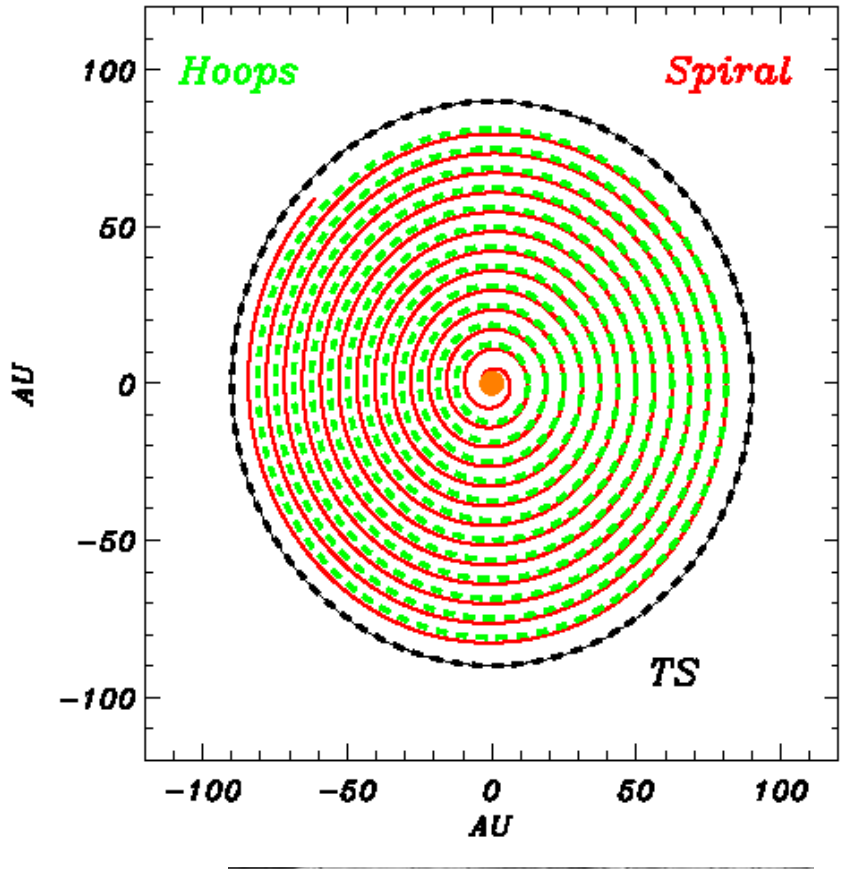
Acceleration of ACRs at the TS: Possible Role of the HCS



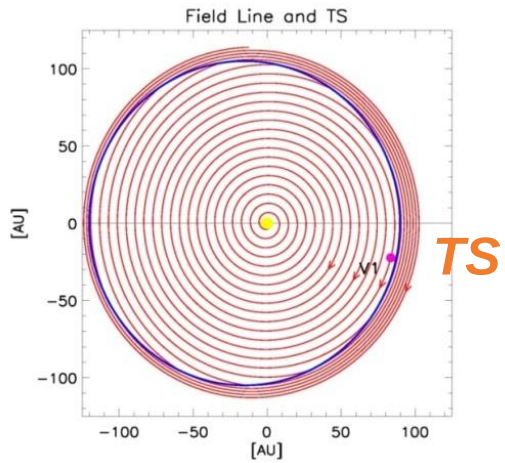
***Motivation**: GCR- ACR disparity at solar minima: GCRs record high, ACRs are not*

***Question**: What is the effect of the HCS on the accelerated source spectrum of ACRs at the termination shock (TS) ?*

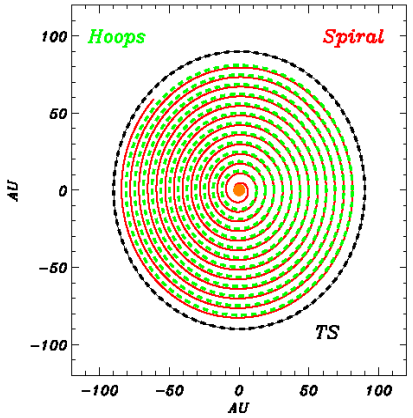
We adopt a "hoop model" that captures the most essential effects of the wavy HCS in a simple 2D time dependent calculation. The model works well beyond >10-20 AU distances from the Sun. It

Hoop model of Parker Spiral Field

Solve Parker's equation in 2-D + energy using ad-hoc parameters



TS



26-day rotation + radial solar wind = tightly wound spiral field

CR transport at r >10 AU is ***dominantly across the spiral*** *field*

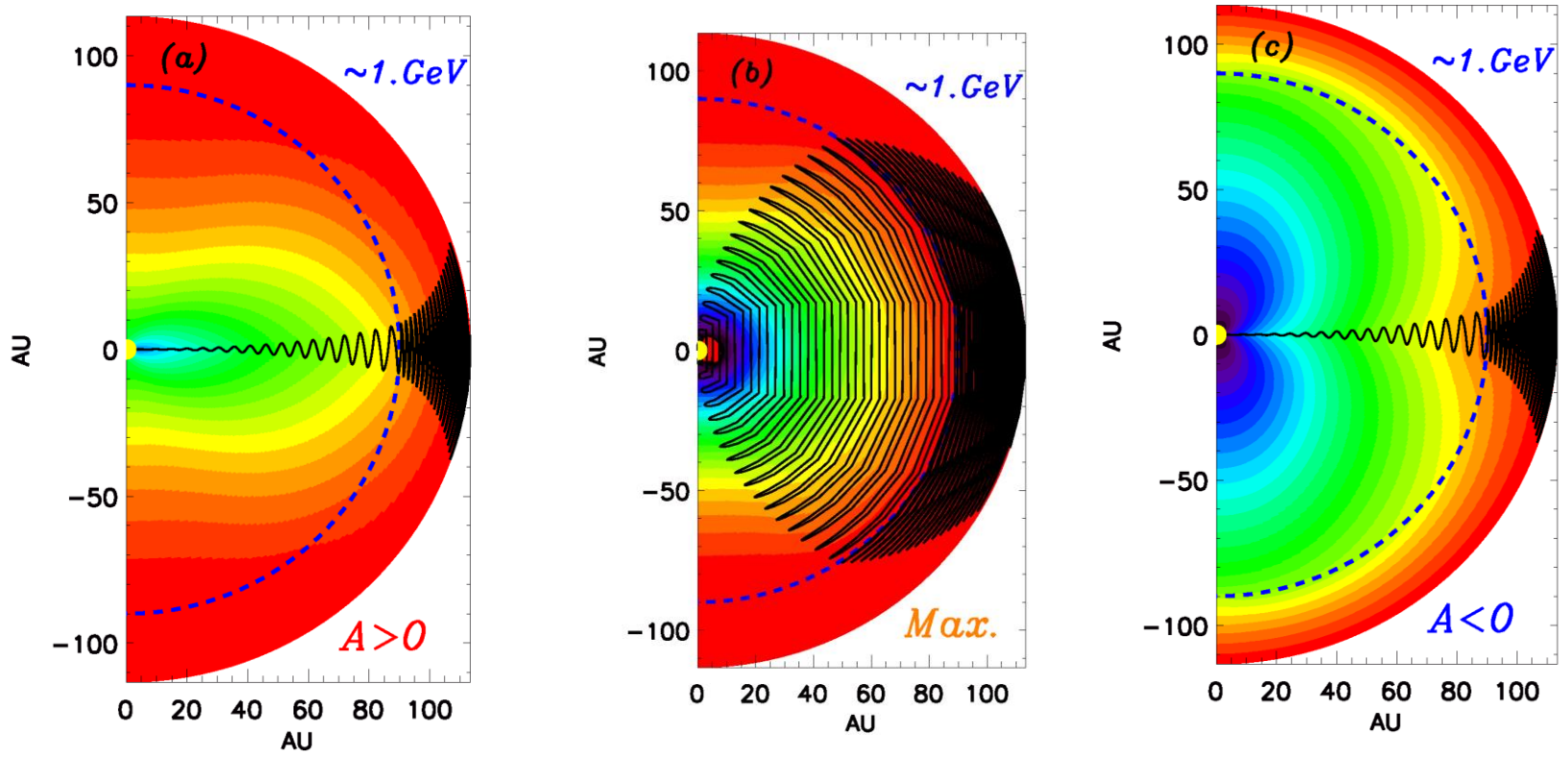
(it is faster to climb the wall than going around – spiral is too long)

*Substitute spiral with hoops: azimuthal symmetry with wavy HCS seamlessly changing the tilt angle continuously (****time-variations)***

22 Year variation of GCRs & ACRs in the hoop model

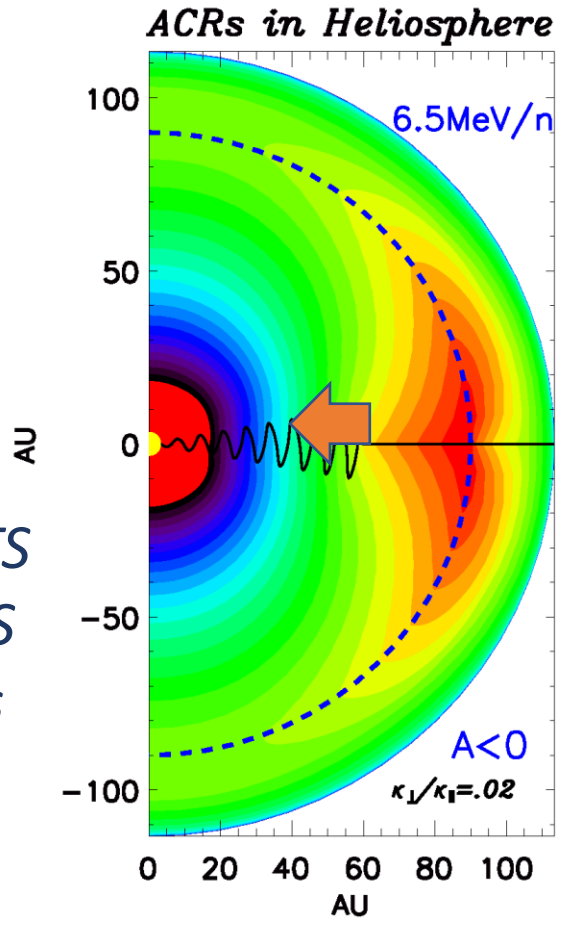
Solar Min A>0 | Solar Max. | Solar Min. A<0

GCRs:

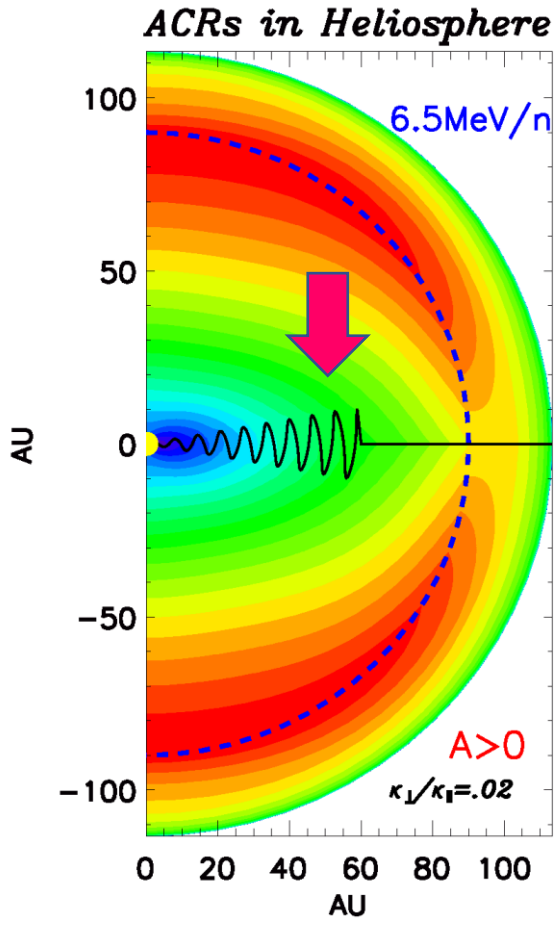


ACRs: Simulations starting from flat HCS (Solar Minima)

A< 0 Drift:
Equatorward along TS
Inward along the HCS
Best injected at Poles



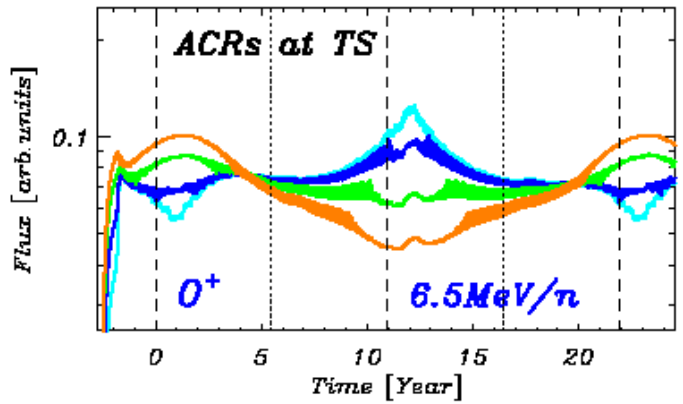
A<0

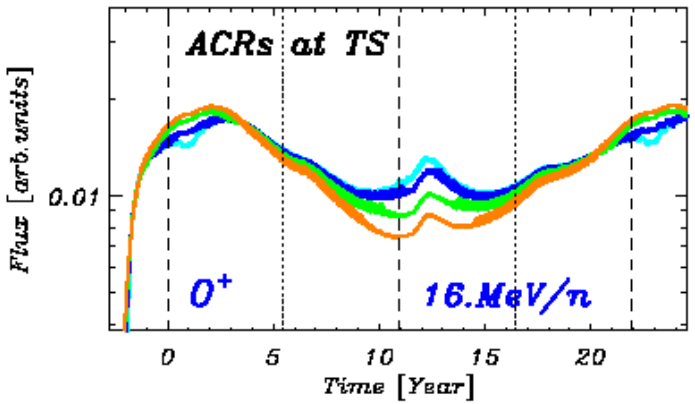


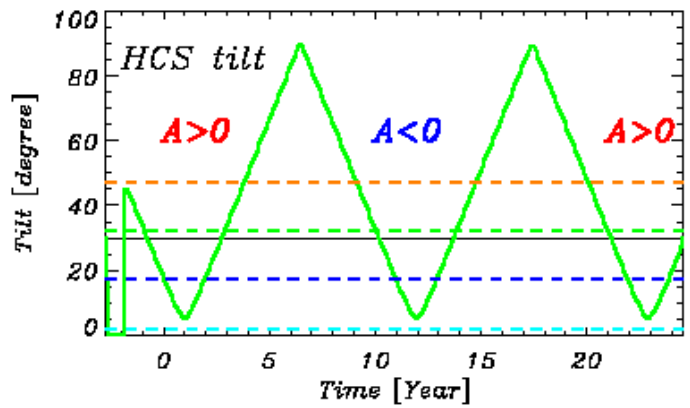
A>0

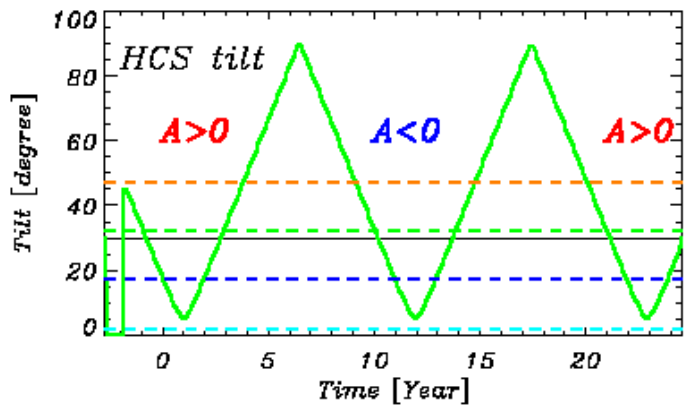
A>0 Drift:
Poleward along TS
Pole to Equator
Best if injected near Equator

Example: 22-year cycle in the accelerated source spectrum of ACRs at the TS at different latitudes









22 yr Cyclic variation
Is energy dependent
& can be significant

Line width indicates
26-day variations

The only quantity to change is the tilt-angle of the HCS.
Polarity is reversed seamlessly.

Motivation and Summary

- *GCRs and ACRs tend to track each other quite closely. During recent solar minima, however, GCRs reached record high level, ACRs did not (Mewaldt, 2010)*

- *GCRs and ACRs have similar transport properties but distinctly different origin. Their disparity suggests that the source spectrum of ACRs at the TS may have been weaker.*
- *Weaker source spectrum can be caused by a number of possible reasons (Moraal & Stoker, 2010; Leske et al. 2013).*

- *Here we single out the HCS and mimic a 22-year cycle, where the HCS tilt changes, while everything else remain constant.*

- *The changing polarity and tilt leads to time variations of the source spectrum which may be significant*

- *Drift & cross field diffusion are coupled (think of the inverse κ tensor). Drift along the wavy HCS, can, among others, increase the "effective" latitudinal transport and make the distribution of ACRs 'more spherical'.*