

#### Why the speeds at Voyager 1 and 2 are so different?



Voyager 1



Voyager 2

## What happened to the missing azimuthal magnetic flux at Voyager 1?



Conservation of magnetic flux:  $B_T V_R R$  = constant

However, while VR was decreasing B was constant <B> = 0.1 Expect corresponding increase in magnetic field



Richardson et al. 2013



The outer heliosheath inside the sector region is filled "bubble"-like structures of magnetic field- the bubbles are convected to higher latitudes by the heliosheath flows



Opher et al. ApJ 2011

### Old and a New View: The permeable heliosphere



## Magnetized jets driven by the sun: The structure of the heliosphere revisited



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#### Classical View of the Heliosphere:

Comet-like shape with a long tail; extending to 1000's of AUs



This view comes from the assumption that even though the solar wind becomes subsonic at the termination shock as it flows down the tail is able to stretch the solar magnetic field.

# Two-lobe structure heliosphere: similar to astrophysical jets



Side view

Nose view

The heliopause is captured at the iso-surface of InT=12.7; the gray lines are the solar magnetic field lines; the red lines are the interstellar magnetic field.  $_{8}$ 

## **Turbulent Lobes (Jets)**



Everywhere downstream of the termination shock  $P_{ram}/P_B < 1$  so the solar magnetic field is strong enough to confine the flow and resist being stretched by the downstream flow.

Cut at y=150AU

## **Turbulent Lobes (Jets)**



The distance to the heliopause down the tail between the two lobes is 250AU (as opposed to 560AU in the case with no  $B_{ISM}$ ).

The lobes are eroded as a result of instabilities and reconnection in the flanks

Cut at y=150AU

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## **Porous Layered Heliopause**



Swisdak, Drake, Opher ApJL 2013



Fig. 1. Overview of energetic particle observations at V1, 2012.35 to 2013.40, showing the contrary behavior of GCRs and lower-energy particles. (A) Hourly averages of GCR activity and the pronounced boundary crossing on 25 August 2012 (day 238). GCR error bars are  $\pm 1\sigma$ . (B) Intensities of low- to medium-energy ions and low-energy electrons. The time evolution is very different, depending on energy and species.



Is Voyager 1 still inside the Heliosphere? Magnetic Field is Solar Like!



Burlaga et al. *Science* 2013

#### And then....



Voyager 1 detected interstellar densities!

Gurnett et al. Science 2013

## Announcement that Voyager 1 is (since end of August 2012) in interstellar space



Several people still thinking that Voyager 1 is in the Heliosheath (e.g. Fisk & Gloeckler 2013; McComas & Schwadron 2012; Schwadron & McComas 2013).

#### HOW FAR THE HELIOSPHERE AFFECTS THE ISM? STRONG TWIST OF THE INTERSTELLAR MAGNETIC FIELD ahead of the Heliopause



#### Opher & Drake ApJL, in press 2013