

# PUIs ENAs and ACRs

a trio of acronyms

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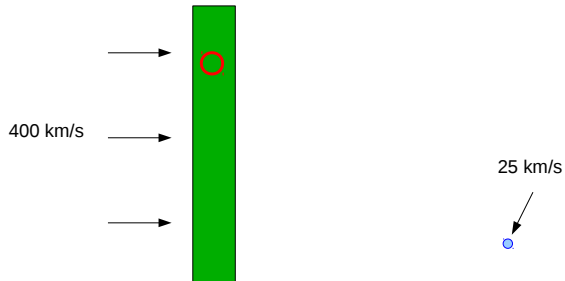
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Neutral atoms originating from high energy ions from  $\sim 10$  eV to  $\sim 1$  MeV  
Allow us to "see" invisible signatures of these ions from quite a long way away

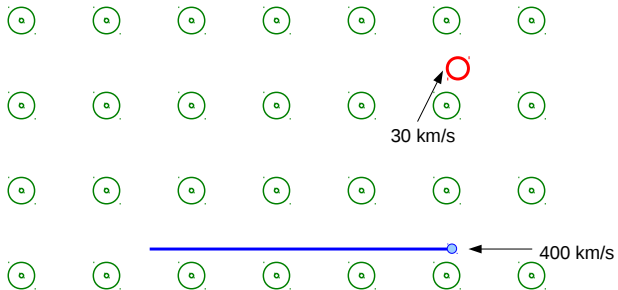
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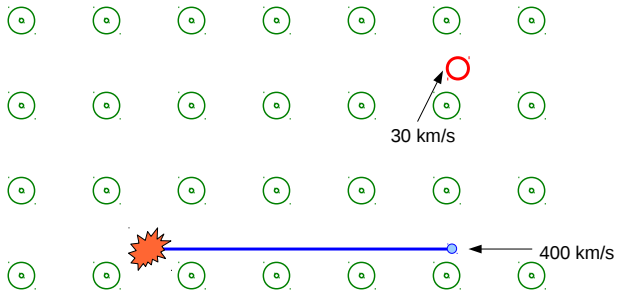
# Picture of pick-up process



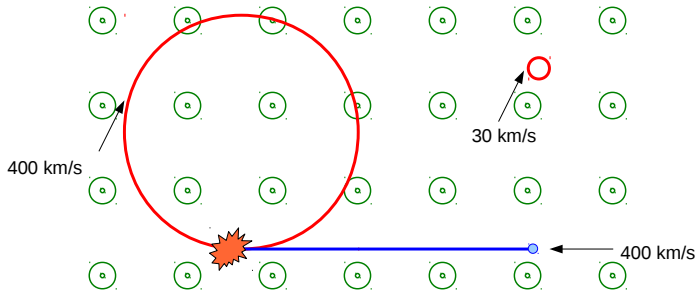
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# How are they ionized?

## Charge Exchange

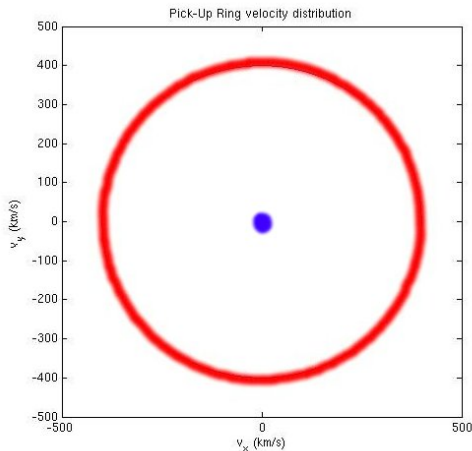
An ion interacts with the neutral atom stealing an electron

## Photo-Ionization

UV Radiation interacts with the outermost electron ionizing the neutral atom

- Photo-Ionization dominates close to the sun
- Past a couple AU, Charge Exchange dominates

# Pick-Up Ring

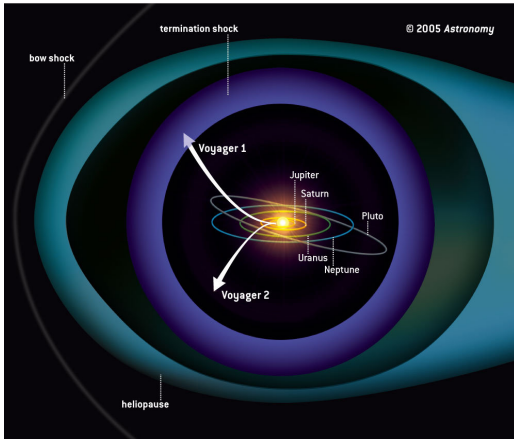


## Pick-Up Ring

A ring shaped phase space distribution caused by pick-up process

- Magnetic field is out of the plane
- There is no preferential gyrophase for the neutrals to be picked up

# Heliosphere description



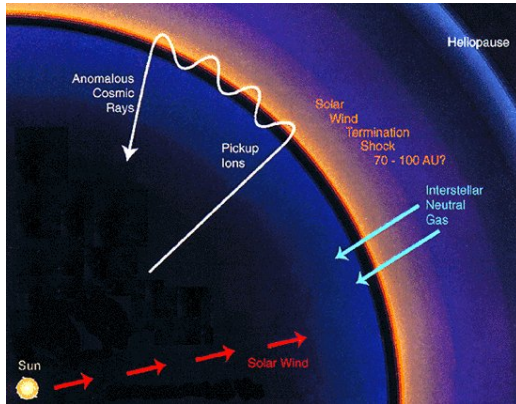
## Heliosphere

The contents of the  
**Heliopause**

## Heliosheath

The region between the  
**Termination Shock** and  
the **Heliopause**

# Anomalous cosmic rays picture



- PUIs get dragged to the heliosheath by the solar wind
- Particles get accelerated here and escape back towards the center of the heliosphere.

# How are they accelerated?

- Fermi acceleration along shocks (Pesses et al. 1981)  
Particles bounce between the fast upstream inflow and the slower downstream outflow gaining energy each bounce

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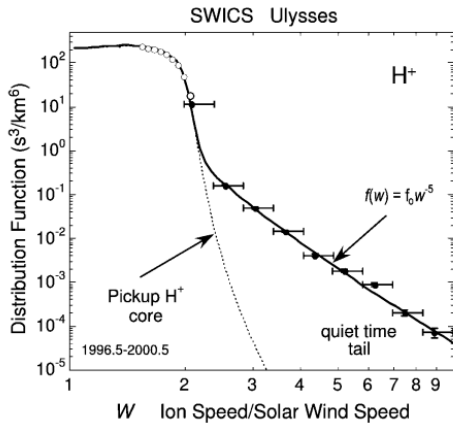
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Random fluctuations of the electric and magnetic fields interact with particles such that they gain energy
- Acceleration within magnetic islands (Oka 2010, Drake et al. 2010)  
Particles interact with reconnection electric fields present near islands, and can be Fermi accelerated in closing islands

# Power law index

A particular power law distribution is predominantly found



(Fisk and Gloekler 2006)

- velocity distribution that goes off like  $v^{-5}$
- this is equivalent to an kinetic energy distribution that goes off like  $E^{-2}$  (Differential number density)
- which is equivalent to an kinetic energy distribution that goes off like  $E^{-1.5}$  (Differential intensity)

# What are ENAs?

- Opposite of PUIs
- Energetic ions that gain an electron and become neutral
- Allows us to see from remote locations where the neutralization takes place



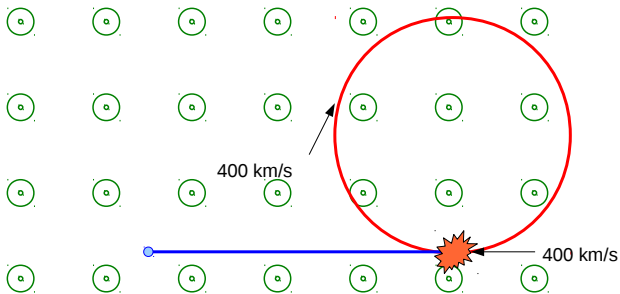
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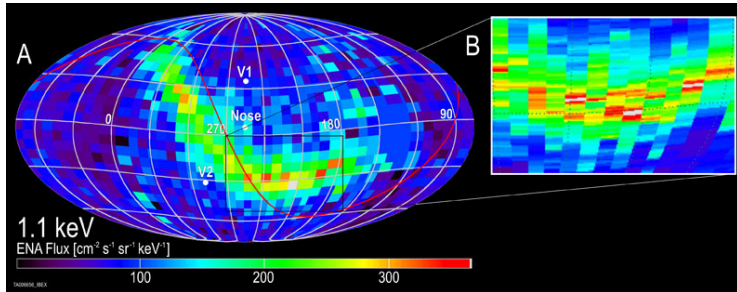
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# What satellites look at them?

## Satellites Measuring ENA's

- Cassini (INCA) (1997-present)  
Looks at the magnetosphere of Saturn
- IMAGE (2000-2005)  
Looks at the Earth's magnetosphere
- TWINS (2008-present)  
Looks at the Earth's magnetosphere
- IBEX (2008-present)  
Looks at an all sky view of the Heliosheath



(McComas et al. 2009)

- A ribbon shaped signature of ENAs found around the nose of the heliosphere
- There is still no consensus on the source of this ribbon

- PUIs (Pick-Up Ions)  
a core set of high energy ions that can be accelerated to become ACRs
- ACRs (Anomalous Cosmic Rays)  
high energy particles  $\sim 1-100$  MeV that were accelerated by at least one of the contending acceleration mechanisms
- ENAs (Energetic Neutral Atoms)  
let us see things like the ribbon or a global picture of the Earth's magnetosphere