

PUIs ENAs and ACRs

a trio of acronyms

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High energy ions that contend with "real" cosmic rays in energy ~ 1 -100 MeV

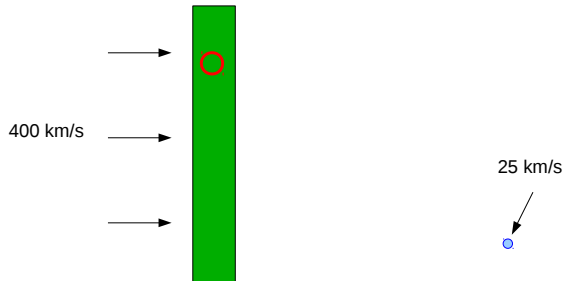
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Neutral atoms originating from high energy ions from ~ 10 eV to ~ 1 MeV
Allow us to "see" invisible signatures of these ions from quite a long way away

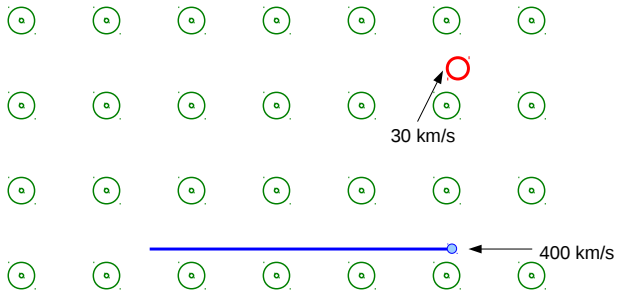
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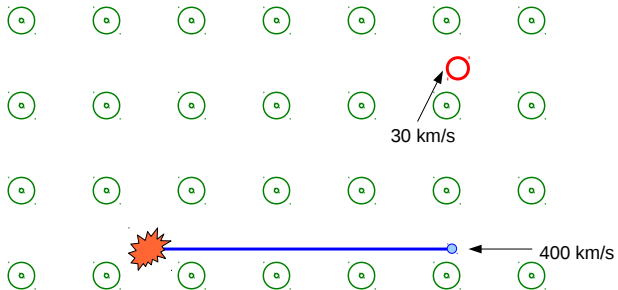
Picture of pick-up process



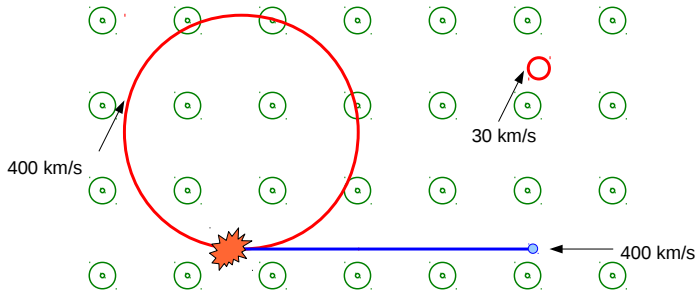
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How are they ionized?

Charge Exchange

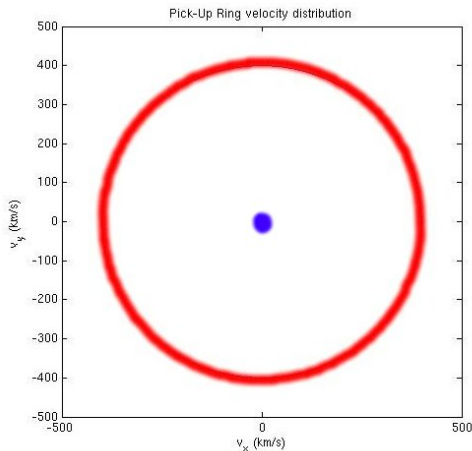
An ion interacts with the neutral atom stealing an electron

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

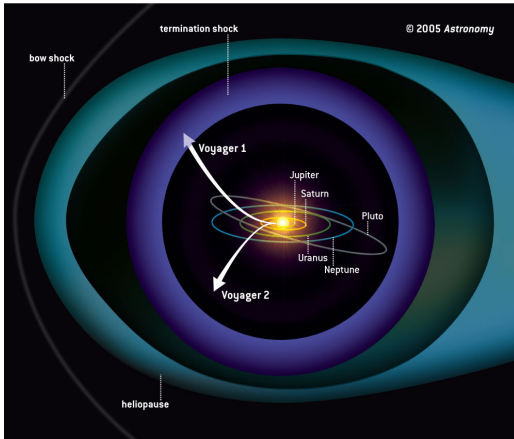


Pick-Up Ring

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



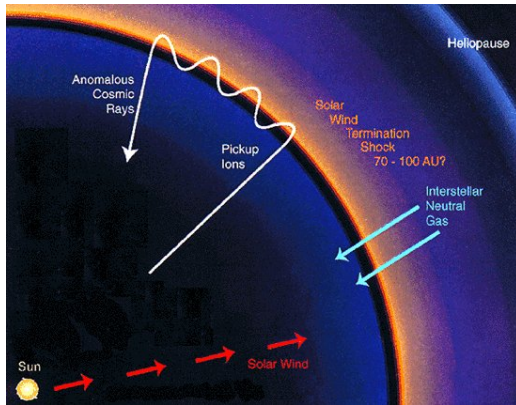
Heliosphere

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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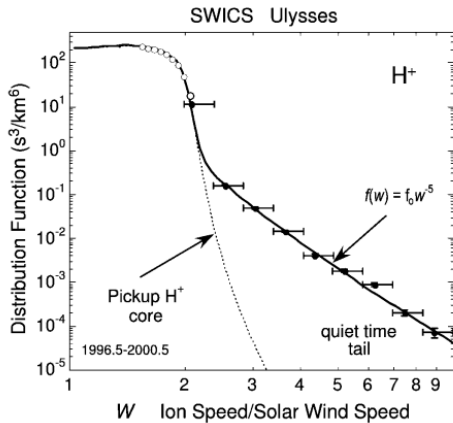
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Random fluctuations of the electric and magnetic fields interact with particles such that they gain energy
- Acceleration within magnetic islands (Oka 2010, Drake et al. 2010)
Particles interact with reconnection electric fields present near islands, 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 a kinetic energy distribution that goes off like E^{-2} (Differential number density)
- which is equivalent to a kinetic energy distribution that goes off like $E^{-1.5}$ (Differential intensity)

What are ENAs?

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



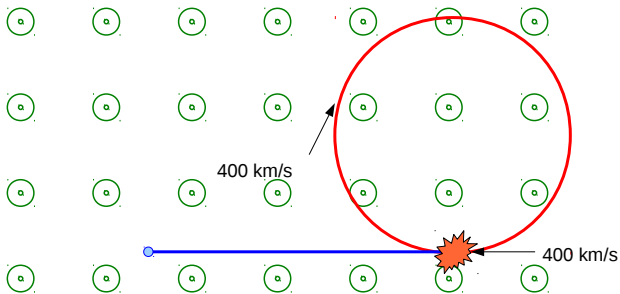
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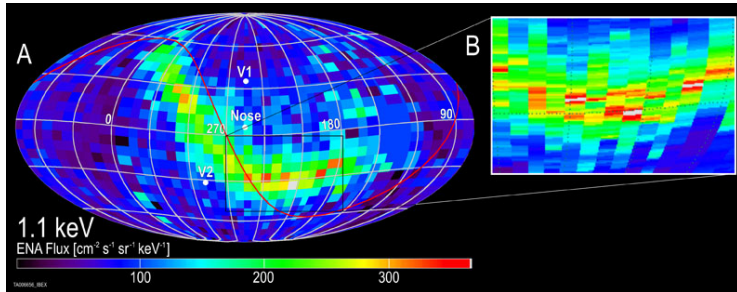
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What satellites look at them?

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 $\sim 1\text{-}100$ 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