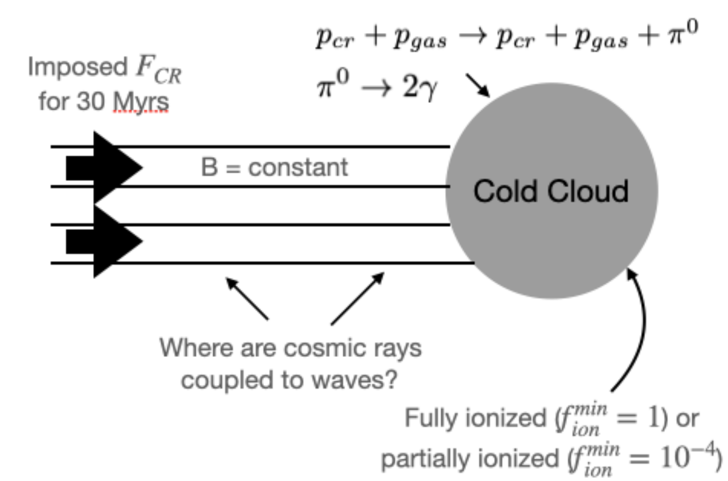
Cosmic Ray Transport, Energy Loss, and Influence in the Multiphase ISM

Chad Bustard (Kavli Institute for Theoretical Physics), Ellen G. Zweibel (University of Wisconsin-Madison)
Reference: Bustard and Zweibel 2021, ApJ 913, 106 (https://arxiv.org/abs/2012.06585)

Why is this important:

- Focused, high-resolution simulations are needed to understand how cosmic rays navigate and influence small-scale, multiphase gas structures under-resolved in galaxy-scale simulations.



What we do:

- We use MHD+CR simulations to probe cosmic ray interactions with individual cold clouds and series of clumps, taking into account fast cosmic ray transport in partially neutral gas — "ionization-dependent transport."

Some results:

- Cosmic ray momentum and energy transfer are concentrated at cloud interfaces for partially neutral clouds; variations in Alfven speed induce cosmic ray "bottlenecks" that allow cosmic ray pressure gradients to form and accelerate the clouds. Bottlenecks at partially neutral clouds are only well-captured if the cloud interface is well-resolved — a condition unlikely to be satisfied in large-scale simulations.

- There are clear spatial differences in gamma-ray emission if ionization-dependent transport is included or neglected, but the total gamma-ray luminosity is, interestingly, largely unchanged.

- Weak magnetic fields are easily influence by pressure perturbations, and field line draping around cold clouds funnels cosmic rays through the intercloud medium, rather than into cold clouds. This has implications for the acceleration of cold clouds in galactic winds that we plan to study further.