Abstract Submitted
for the APR21 Meeting of
The American Physical Society

Ab-initio Simulations of Cosmic Ray Escape from Their Sources[1]
DAMIANO CAPRIOLI, University of Chicago, BENEDIKT SCHROER, ORESTE PEZZI, Gran Sasso Science Institute, COLBY HAGGERTY, University of Chicago, PASQUALE BLASI, Gran Sasso Science Institute — We explore the escape of energetic cosmic rays (CRs) from their sources via hybrid (kinetic protons-fluid electrons) plasma simulations. For the first time, we self-consistently find that the excitation of streaming instabilities leads to enhanced CR diffusivity and in turn to a large pressure gradient that causes the formation of expanding bubbles of gas and self-generated magnetic fields. This phenomenon is general and is expected to occur around any sufficiently powerful CR source in the Galaxy. Our results provide a theoretical framework for explaining recent observations of gamma-ray haloes around supernova remnants, stellar clusters and pulsar wind nebulae, which are interpreted as regions where the diffusion coefficient is 10-100 times smaller than the typical Galactic one. Finally, we outline the potential role of such regions for the feedback that CRs may exert on star formation.

[1]Simulations were performed on computational resources provided by the University of Chicago Research Computing Center, the NASA High-End Computing Program through the NASA Advanced Supercomputing Division at Ames Research Center, and XSEDE TACC (TG-AST180008). DC was partially supported by NASA (grants NNX17AG30G, 80NSSC18K1218, and 80NSSC18K1726) and by NSF (grants AST-1714658, AST-1909778, and PHY-2010240).

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Date submitted: 08 Jan 2021 Electronic form version 1.4