Cosmic Rays: A View Into Galactic Interactions and the New Physics

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Introduction

Galactic interactions result in large-scale shock waves that impact the interstellar medium, affect the evolution of galaxies and trigger star-formation. They can be a new source of cosmic rays accelerated in large-scale tidal shocks – tidal cosmic rays (TCRs). TCRs would impact light element abundances and non-thermal radio emission of interacting galaxy. It would be sufficient for the entire gas of the Small Magellanic Cloud to be shocked only twice, to accelerate enough TCRs to produce as much lithium as galactic cosmic-rays (GCRs) have made throughout its history.

Star-forming galaxies

- Far-infrared (FIR) emission - dust heated by the UV radiation from young massive stars
- Diffuse radio emission - non-thermal synchrotron emission of GCR electrons accelerated in supernova remnants.
- FIR-radio correlation of star-forming galaxies
- Powerful tool for determining star-formation rates of galaxies.

Tidal shocks will affect the FIR-radio correlation in interacting galaxies and estimates of star-formation rates. Here we explore these effects.

FIR-radio Correlation

Far-infrared–radio correlation is defined with parameter

\[ q_R = \log \left( \frac{F_{\text{IR}}}{3.75 \times 10^5 \text{Wm}^{-2}} \right) - \log \left( \frac{S_{\text{212 GHz}}}{\text{Wm}^{-1}\text{Hz}^{-1}} \right) \]

- \( S_{\text{212 GHz}} \) is radio continuum flux at 212 GHz with index \( a \).
- \( F_{\text{IR}} \) is rest-frame far-infrared dust emission flux.

If there was significant impact of tidal shocks on the ISM:
- Early merger - additional heating (increasing \( q_R \)).
- Mid merger - increase in non-thermal radiation as TCRs get accelerated (decreasing \( q_R \)).
- Later merger - star-formation triggered (increasing \( q_R \)).

Results

- We have analyzed 43 available interacting galaxies in various merger stages, and explored possible differences in their radio and FIR emission spectra and luminosities.
- FIR and radio observations indicate that a new cosmic-ray population is potentially present in interacting galaxies.
- Dashed line is the typical value \( q_R = 2.34 \pm 0.21 \), with mean deviation denoted with dotted lines. Mean FIR-radio parameter was also determined for each merger stage separately and presented as filled (red) symbols with blue error bars.

Discussion

- If FIR-radio correlation is affected so will be the star-formation rates (SFR) determined from it.
- SFR determined from radio and infrared observation will be different than the one determined from UV and Hα that should be unaffected.

References