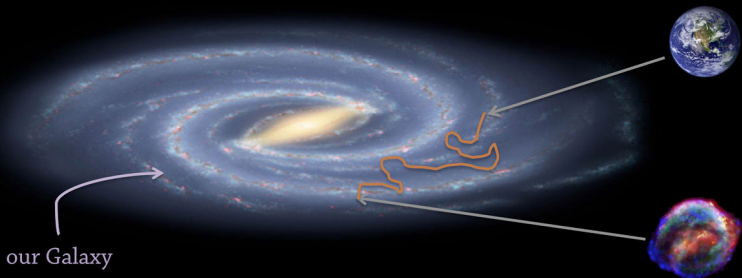


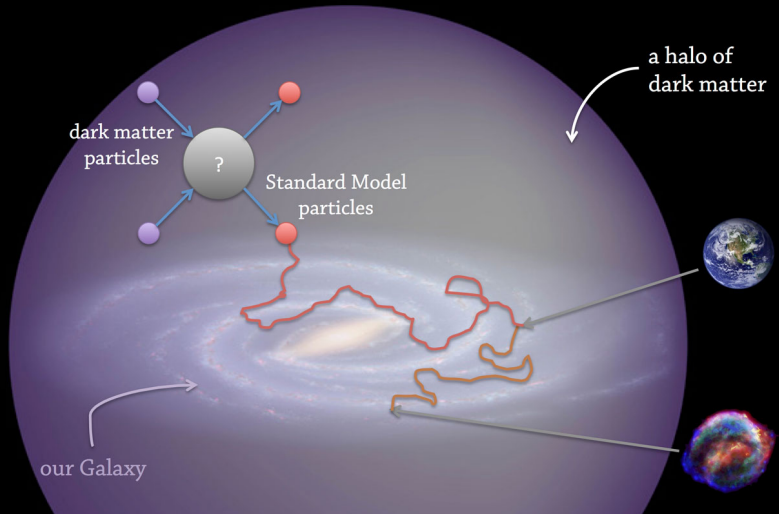
# Bachelor thesis topics 2021

Prof. Dr. Philipp Mertsch  
*with Dr. Minh Phan*

TTK, RWTH Aachen University  
29 January 2021



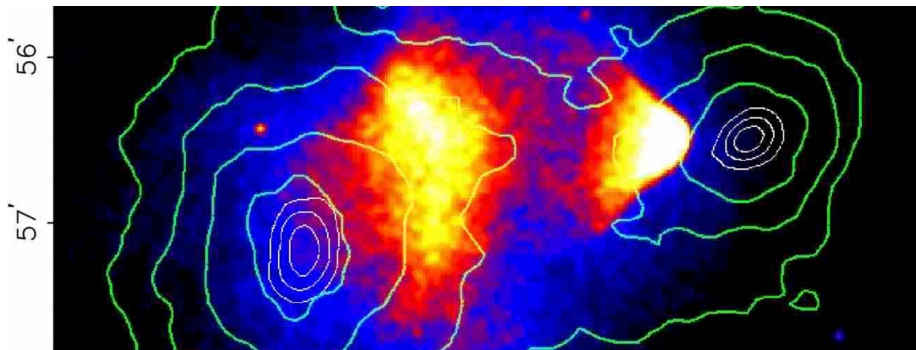
our Galaxy



## Dark matter indirect detection

- Annihilation or decay of dark matter can produce Standard Model particles
- Astrophysical sources also accelerate cosmic rays
- To discriminate, need excellent understanding of the astrophysics

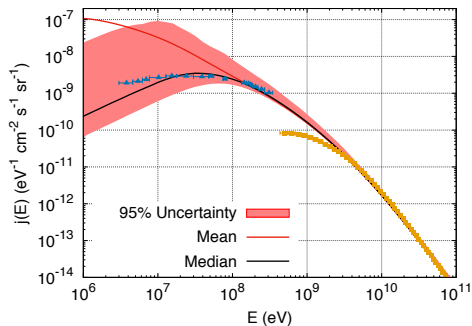
# Millicharged dark matter and plasma instabilities



- Dark matter particle can have tiny electric charges
- Rich phenomenology of (dark) plasma waves
- Not really a collisionless fluid

- Compute the dispersion relation in the cold plasma limit
- Constrain the parameters from non-observation of significant instabilities

# Stochastic fluctuations of low-energy cosmic rays



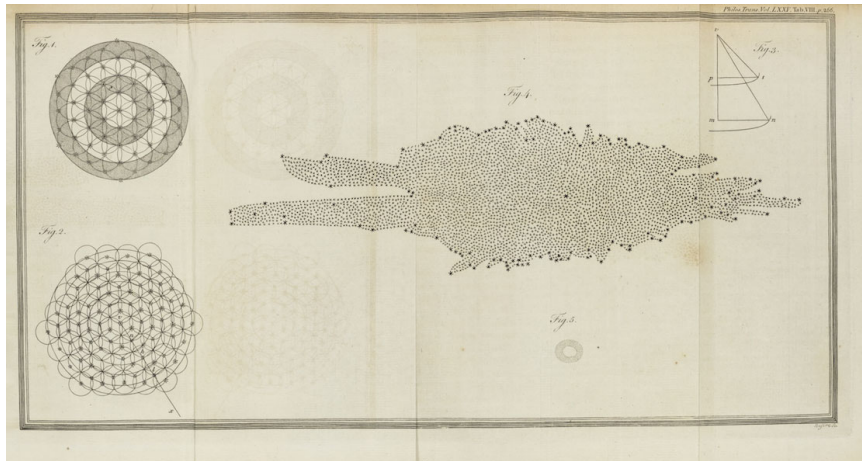
- The flux of cosmic rays varies with position in the Galaxy
  - Taking this into account explains the low-energy measurements
  - But this is in conflict with ionisation from molecular clouds?!
- 
- Model the fluctuations of low-energy cosmic rays with position in the Galaxy
  - Test various non-standard sources, e.g. pulsars, stars

# Nonlinear cosmic-ray transport near supernova remnants

$$\begin{aligned}\frac{\partial P_{\text{CR}}}{\partial t} + v_A \frac{\partial P_{\text{CR}}}{\partial z} &= \frac{\partial}{\partial z} \left( \frac{D_B}{W} \frac{\partial P_{\text{CR}}}{\partial z} \right) \\ \frac{\partial W}{\partial t} + v_A \frac{\partial W}{\partial z} &= -v_A \frac{\partial P_{\text{CR}}}{\partial z} - 2\Gamma_d W + Q\end{aligned}$$

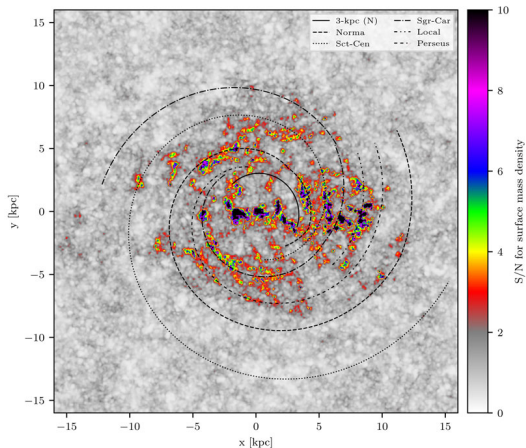
- Cosmic ray density  $P_{\text{CR}}$  and turbulent wave energy  $W$  are coupled:
  - Cosmic rays generate waves, waves scatter cosmic rays
  - Particularly relevant around sources, but so-far widely neglected
- 
- Investigate the coupling of  $P_{\text{CR}}$  and  $W$  in analytical or numerical approach
  - What kind of observations can test such a model?

# A 3D map of the Galaxy



- We can observe gas only in projection
- Gas rotating is around Galactic centre, leads to Doppler shift
- Deproject survey data using Bayesian variational inference

# A 3D map of the Galaxy



- Adopt existing code to produce Galactic map of atomic hydrogen
- Compute the emission of high-energy gamma-rays



Any questions?

Office hour today between 15:00 and 16:00 on Zoom

- Meeting ID: 930 5753 6636
- Passcode: 240931
- Or see Moodle page for the link:  
“Tag der Physik” → “Theo. PPC”