Galactic Foreground Models

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On behalf of the Pan-Experiment Galactic Science Group

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Galactic Emission Modeling

- Our goal is to deliver maps of Galactic emission that:
  - Cover the full sky: self-consistent for Pole and Chile
  - Cover the full microwave (+FIR+radio) frequency range
  - Are constrained by the latest observations where they exist
  - Make reasonable extrapolations where data do not exist
  - Contain realistic sky complexity relevant for CMB analysis
  - Are vetted by experts in the physics of the interstellar medium
- The maps used for DC0 are the latest iteration in this effort, making substantial improvements to the previous generation of simulations

Pan-Experiment Galactic Science

- Work coordinated through the **Pan-Experiment Galactic Science Group**: experts in Galactic astrophysics and CMB foregrounds across most of the current and upcoming CMB experiments, as well as interested members of the ISM community
- Group effort from many contributors, including Giuseppe Puglisi, Andrea Zonca, Jacques Delabrouille, Nicoletta Krachmalnicoff, Kenny Lau, Mathieu Remazeilles, Shamik Ghosh, Ben Thorne, Jian Yao, Elisa Russier, Susan Clark, Brandon Hensley++
- Pooling expertise on data products, CMB analysis, software, and Galactic astrophysics to deliver public software for simulations of Galactic emission over the full sky at any microwave frequency

Software: PySM

- Python Sky Model: https://github.com/galsci/pysm
- Tool for generating full sky maps of Galactic emission at any (FIR/microwave/radio) frequency and including a number of emission mechanisms (dust, synchrotron, free-free, spinning dust, CO)
- Different models for each foreground component so level of complexity of simulations can be tuned

PySM v3.4.0 and DC0

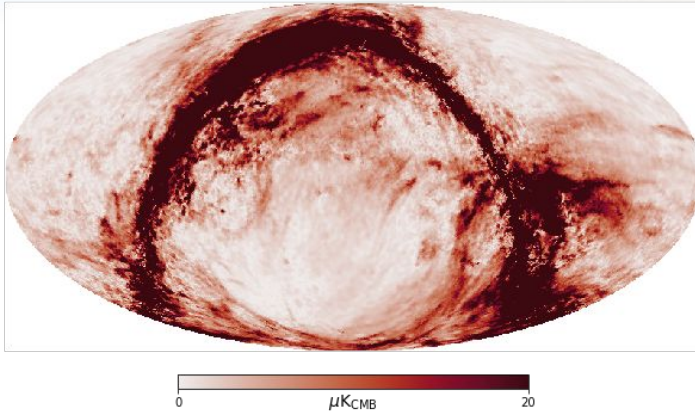
- New Galactic dust and synchrotron models form the core of a major new PySM release:
  - Updated emission templates to be consistent with the latest data + component separation analyses
  - Stochastic small scales to arbitrarily high ell, including in spectral parameters, that can form the basis of a suite of simulations
  - Implementation of the “MKD” layer model which features line-of-sight frequency decorrelation
- DC0 maps intended to be same as first 3.4.0 stable release, in final stages of validation

DC0 Model Summary

- Three sky models, all consistent with current data:
  - **Medium Complexity:** Parameter maps based on component separation with extrapolation to small scales in both amplitudes and spectral parameters
  - **Low Complexity:** Small-scale fluctuations in amplitudes only, no decorrelation
  - **High Complexity:** Near maximum-allowed decorrelation for dust emission, line-of-sight dust SED variations, AME polarization, synchrotron curvature
- Also being used by SO and LiteBIRD (including proposed S4+LiteBIRD work)
- ApJ paper being written
- We're eager for feedback! Please let us know if these models meet your simulation needs

Available on Github: https://github.com/galsci/pysm

353 GHz P



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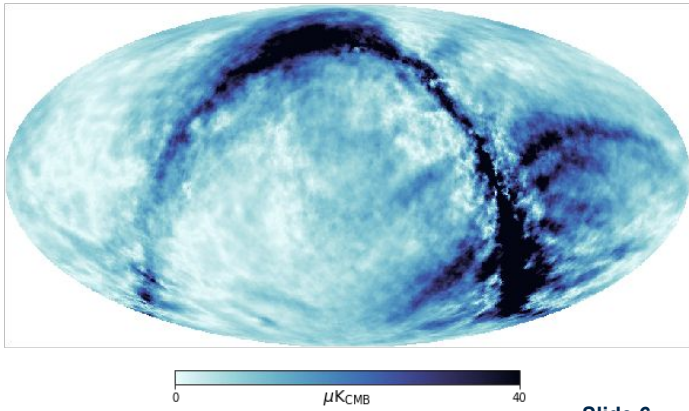

Future Outlook

- Possible extensions of current model suite to allow for finer grained control and closer match to data in various statistics (e.g., allow certain model parameters to be tunable by the user)
- On DC1 timescale, investigate promising new methods for generating realistic small scales
  - Machine learning methods
  - Higher order statistics
- All are invited to join the development in the Pan-Ex group meetings Wednesdays at 11 AM ET / 8 AM PT