Using hydrogen data to trace the galactic magnetic field and dust polarization angle for cosmic microwave background foregrounds

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Introduction

Our view on cosmic microwave background (CMB) is contaminated by several of things like synchrotron radiation and dust polarization is the dominant. Dust polarization angle is tightly connected with the galactic magnetic field. Hence, tracing galactic magnetic field is crucial to dust polarization removal.

Data to trace magnetic field including Rolling Hough transform for density alignment (Clack et al. ,2015) and velocity gradient(Yuen & Lazarian,2017). We examine the methods using a new all sky hydrogen map hi4pi (Bekhti et al. 2016) and compare with PLANCK 353GHz data newly build magnetic field. We found the correlation between them and it can potential help the removal of CMB foreground.

Objective and method

We hope we can reveal to correlation between the linear structure of hydrogen ,velocity and galactic magnetic field.

We apply a transformation call Rolling Hough transformation which can examiner the linear alignment of a 2D image to HI4PI all sky hydrogen data and compare it with PLANCK 353 GHz data in all-sky and low galactic latitude where dust density is large and PLANCK can trace the magnetic field better. We apply a smoothing kernel to PLANCK and RHT output Q and U map to reduce the noise and systematic error. Then calculate the angle using the polarization formula $\theta = 0.5 * \arctan\left(\frac{U}{Q}\right)$. Since the dust will align with the magnetic field with its long axis and polarized with its short axis, we rotate the θ_{353} with 90 degree.

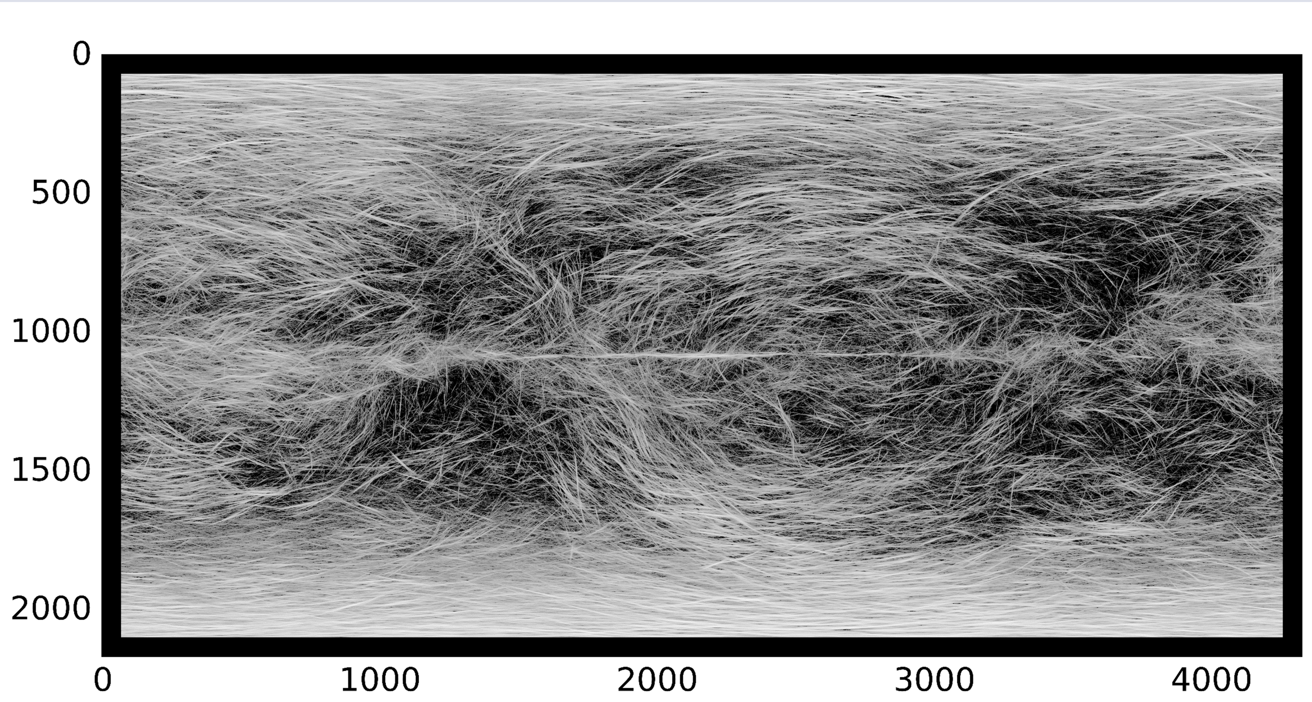

Figure 1.The result of HI4PI data set after apply rolling hough transform

For velocity gradient, we propose a new method to calculate it. However, due to the limitation of current resolution of telescope and velocity channel, we cannot test the method yet.

The method is first calculate the velocity centroid aka the mean velocity $VC = \frac{\int p(x)v(x)dx}{\int p(x)dx}$ like the old method propose by Yuen,2017. Then ,unlike Yuen's method, we approximate the velocity field to be continuous and calculate dx and dy using its nearby pixel value, then the angle by $ang = -\arctan\left(\frac{dx}{dy}\right)$ for IAU polarization convection. This method required a high resolution telescope and we need to wait for the future.

Result and conclusion

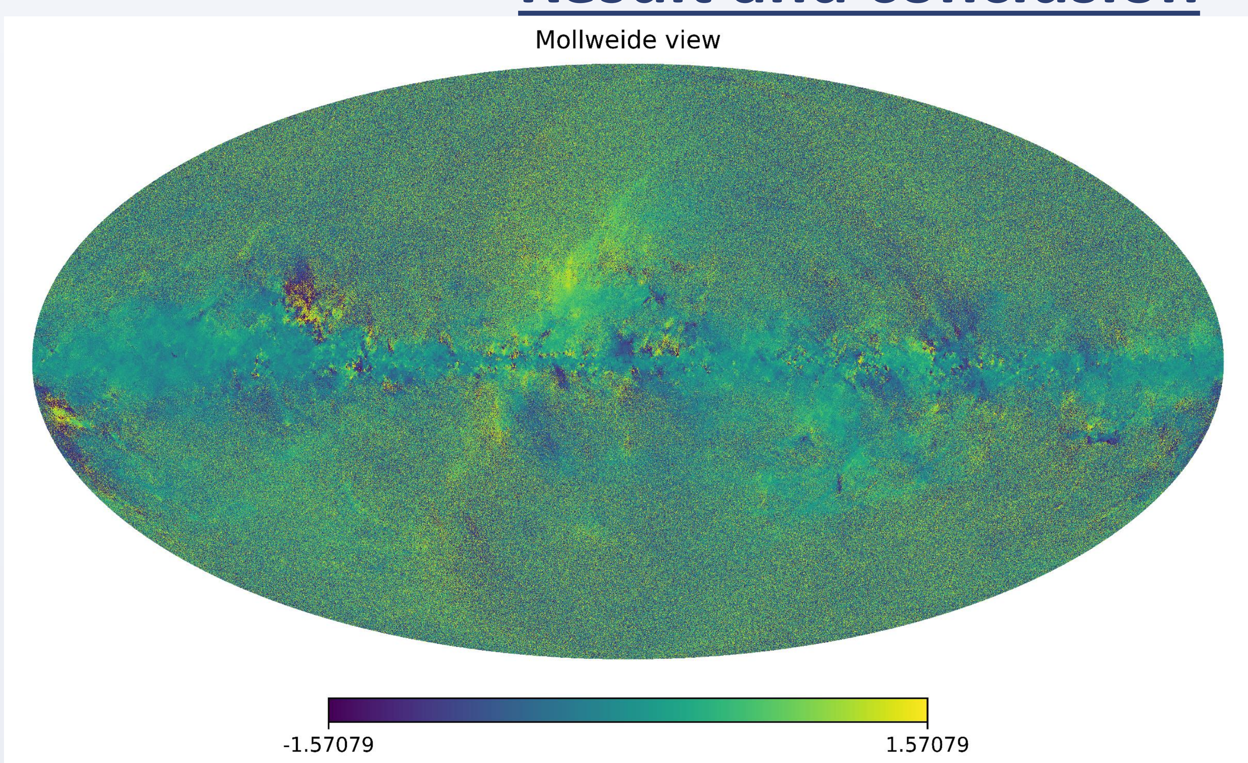

Figure 2.The 353GHz PLANCK polarization map

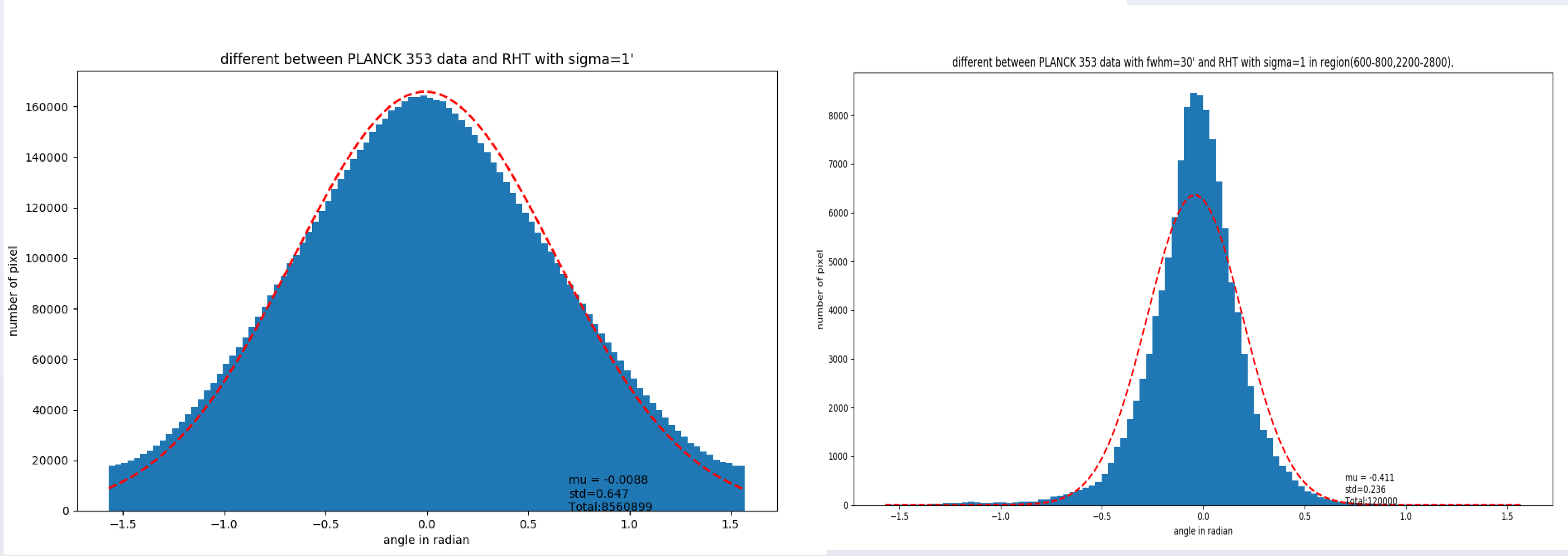

Figure 3. The histogram of the difference between RHT result and PLANCK data

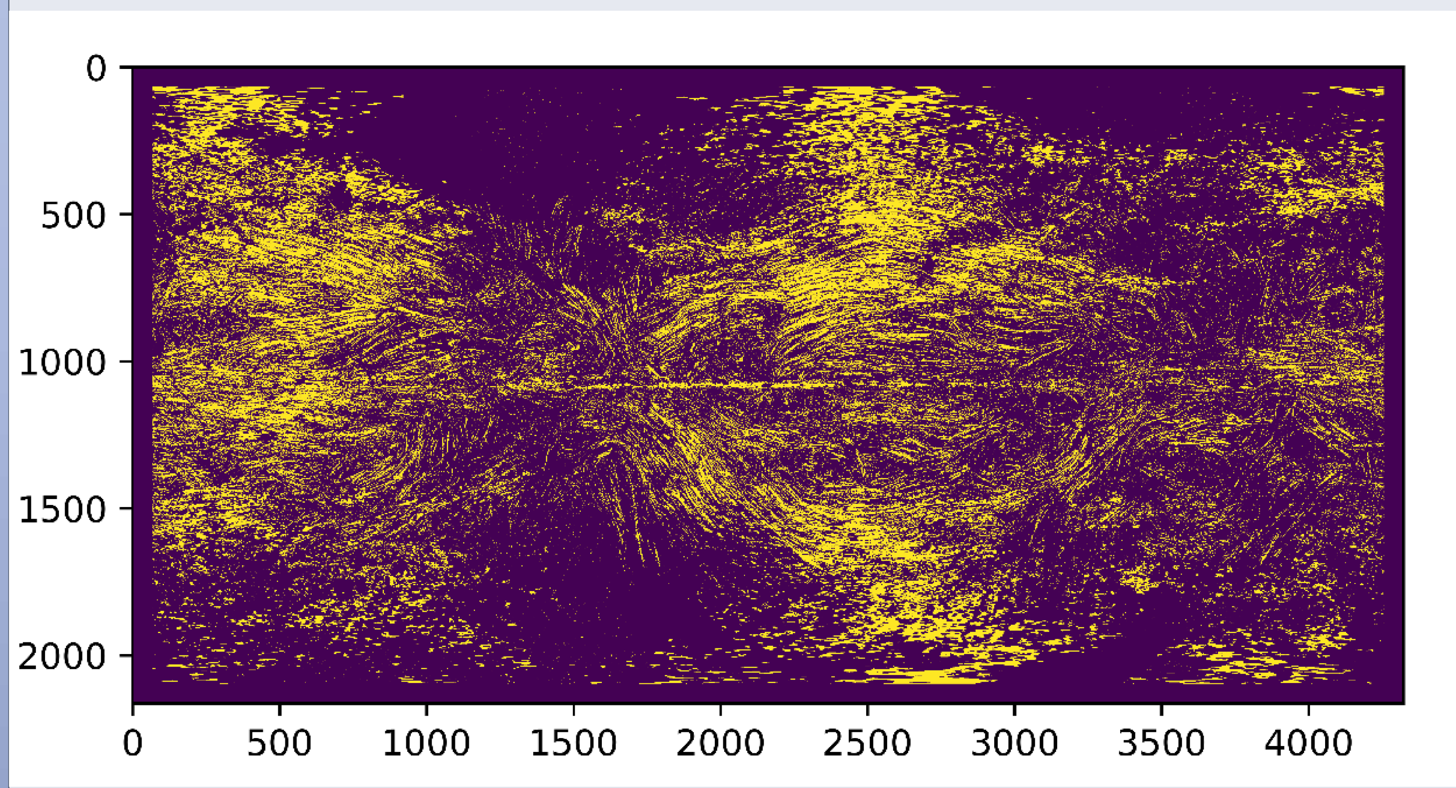

Figure 4.The region where the difference between RHT result and PLANCK data is less that 0.2 radius

As show in the figure, the correlation between linear alignment of hydrogen and magnetic field is strong ,epically in the region of lower galactic latitude where PLANCK is most accurate. The standard deviation 0.236 radian (13.5 degree) and the angle different is concentrated. The figure below is show the region where the difference is less than 0.2 radian and as expected ,the region is concentrated in low galactic latitude.

The show that the linear structure of hydrogen is tightly correlated with magnetic field even for a low resolution telescope and this all-sky data can be used to obtain a better magnetic field model and hence a better foreground model and use to remove the contamination of CMB polarization and finally, find the B-mode polarization of CMB.

References

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