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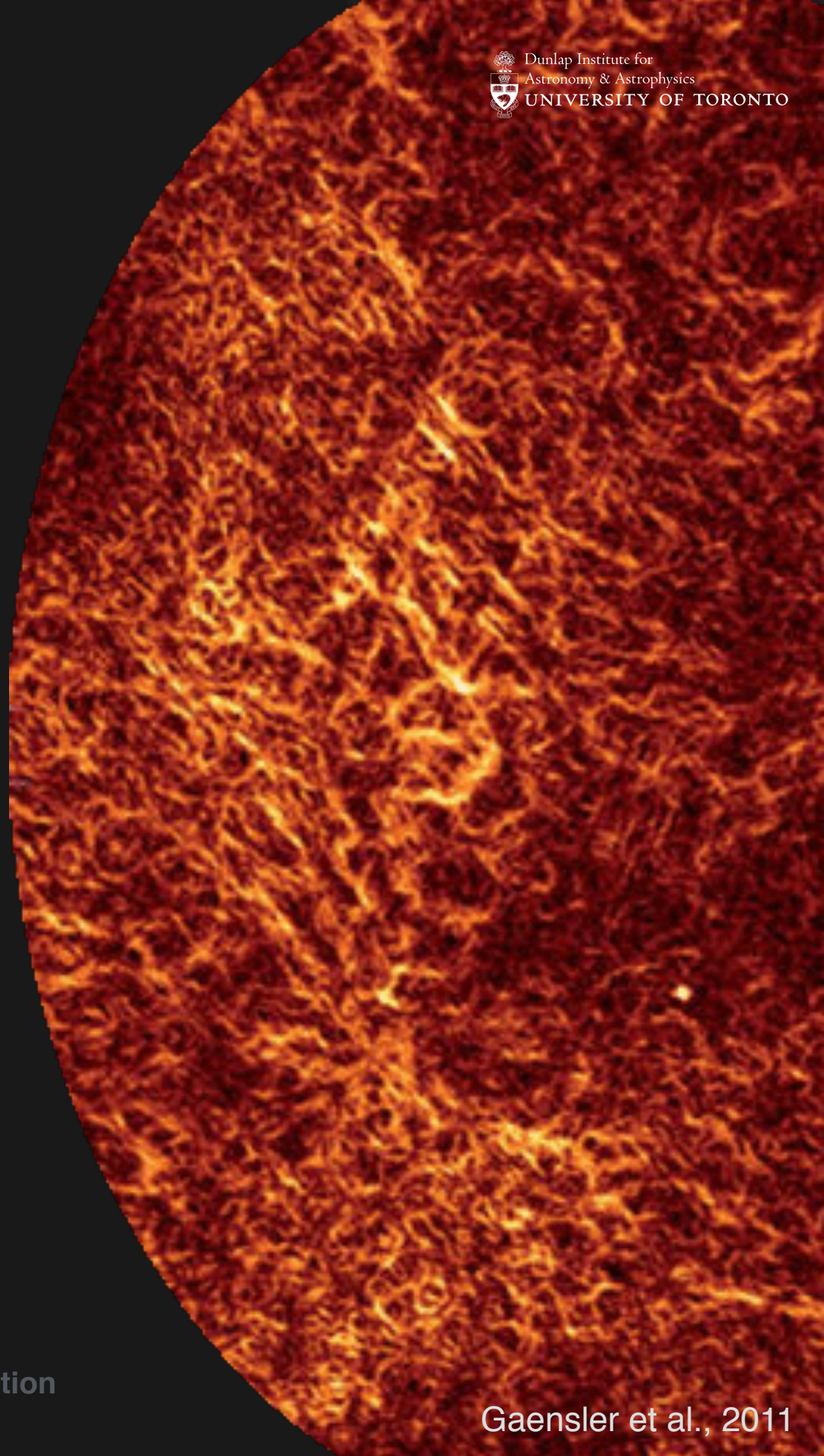
Polarization Gradients as a Probe of Galactic Magnetism

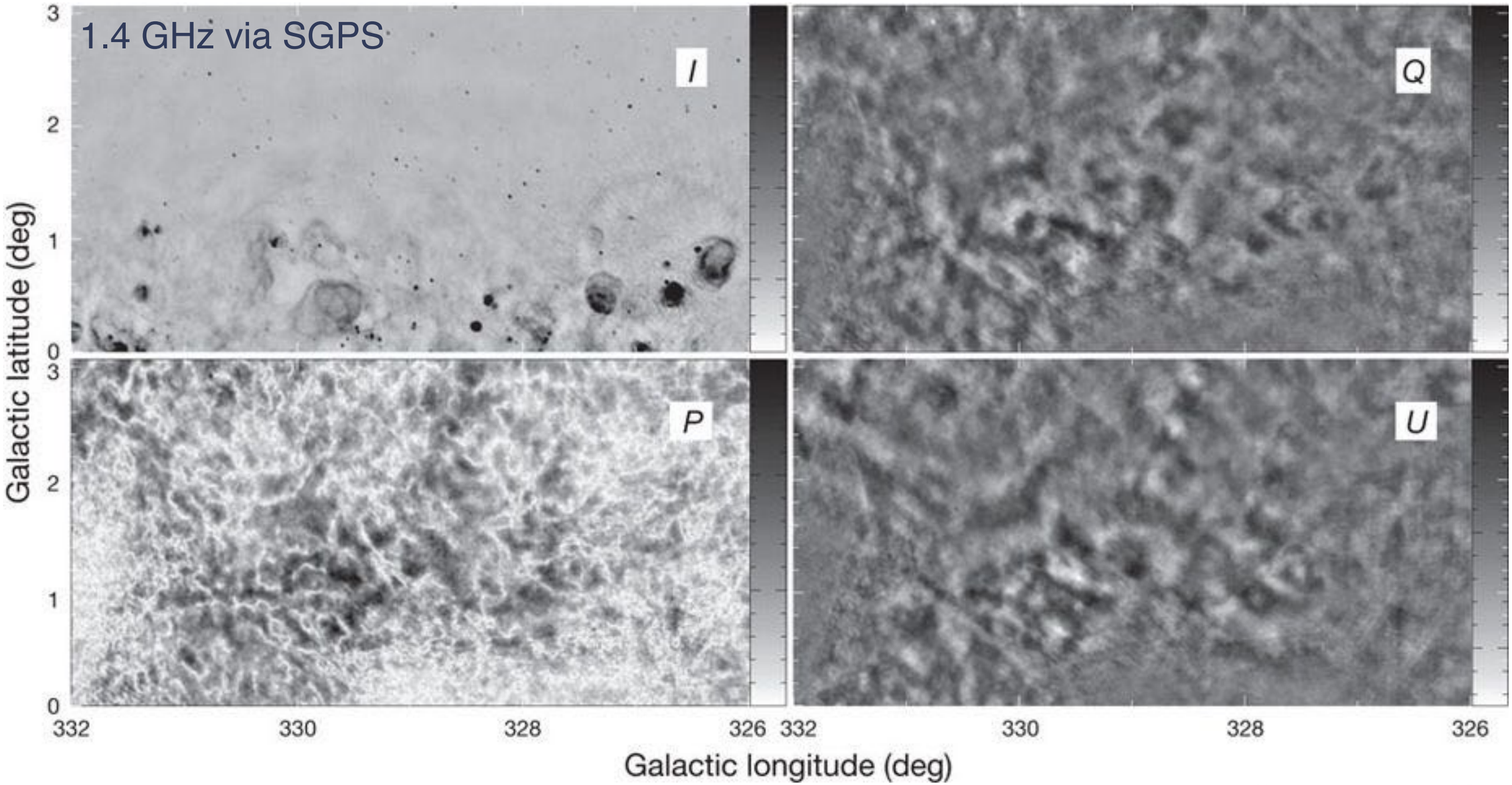
Jessica Campbell

Group Meeting Presentation
March 9, 2018



Gaensler et al., 2011

Unusual Radio Polarization Structures Unseen in Total Intensity



Gaensler et al., 2011

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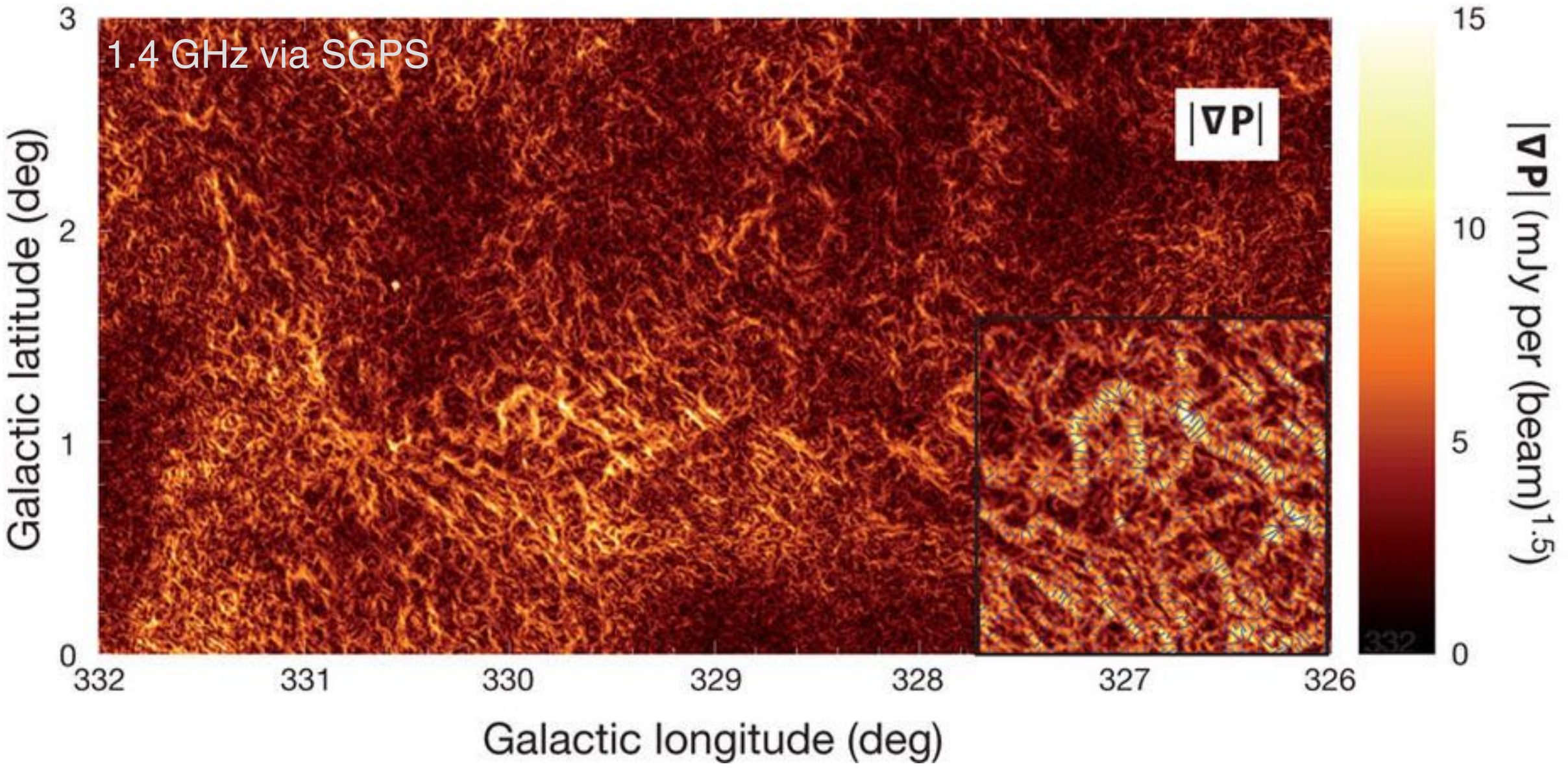

Gaensler et al., 2011

$|\nabla P|$ filaments trace abrupt changes in n_e or $B_{||}$ of MIM

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Q-U Invariance: Polarization Gradient

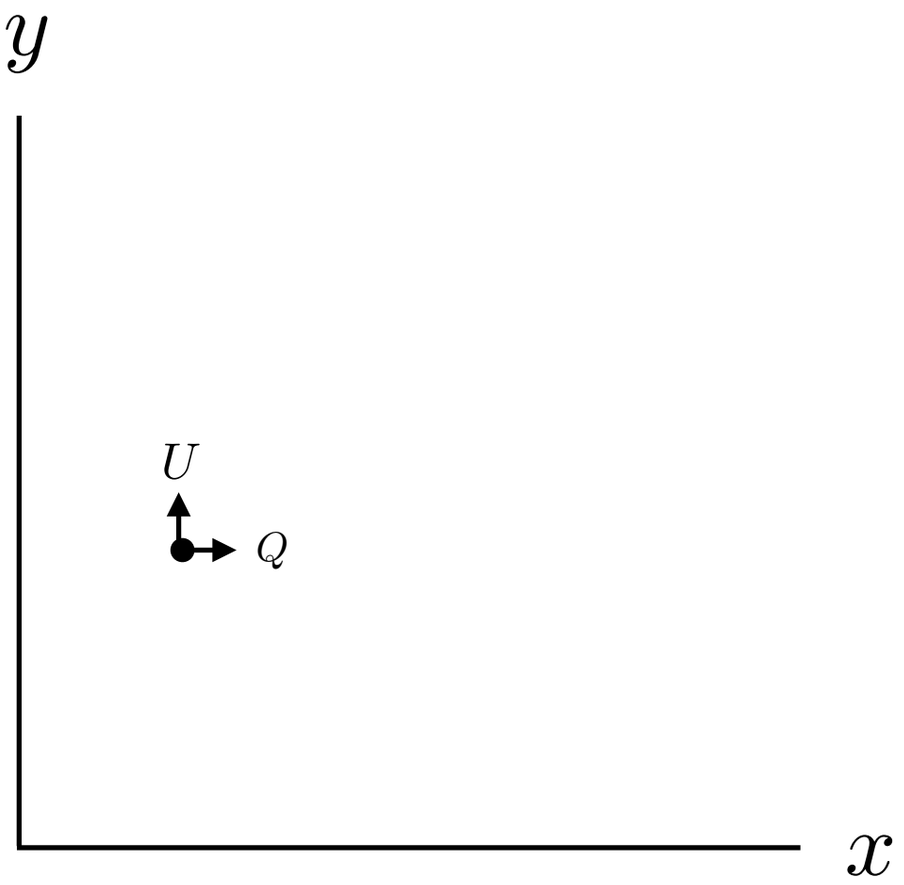
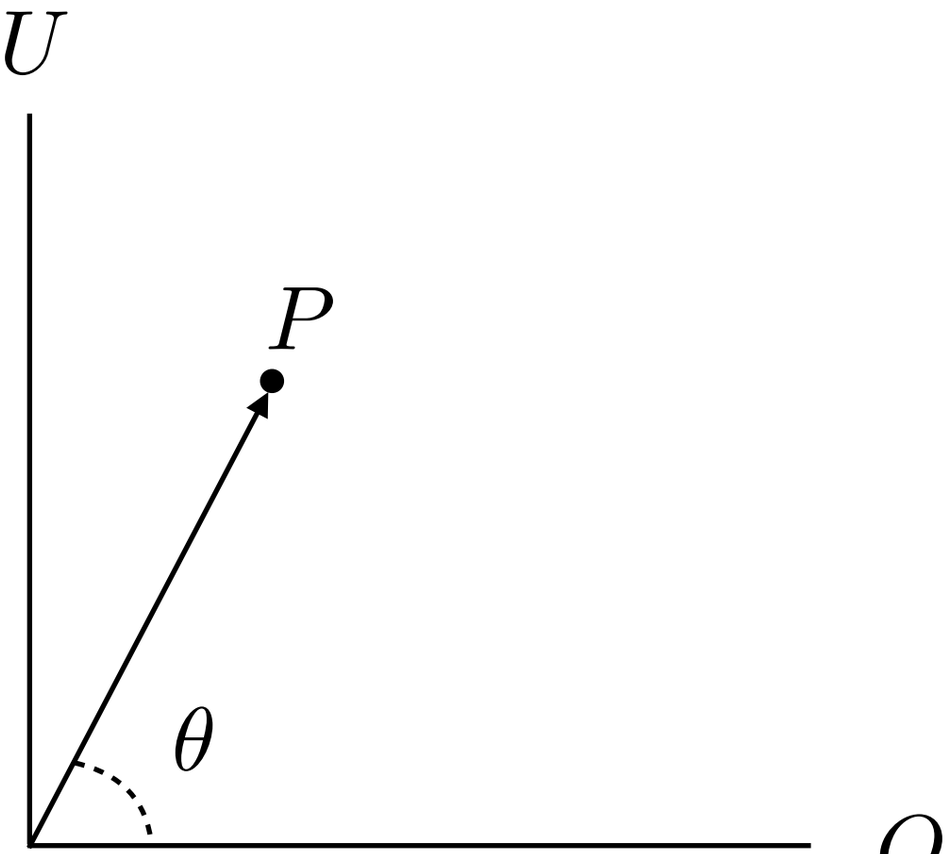
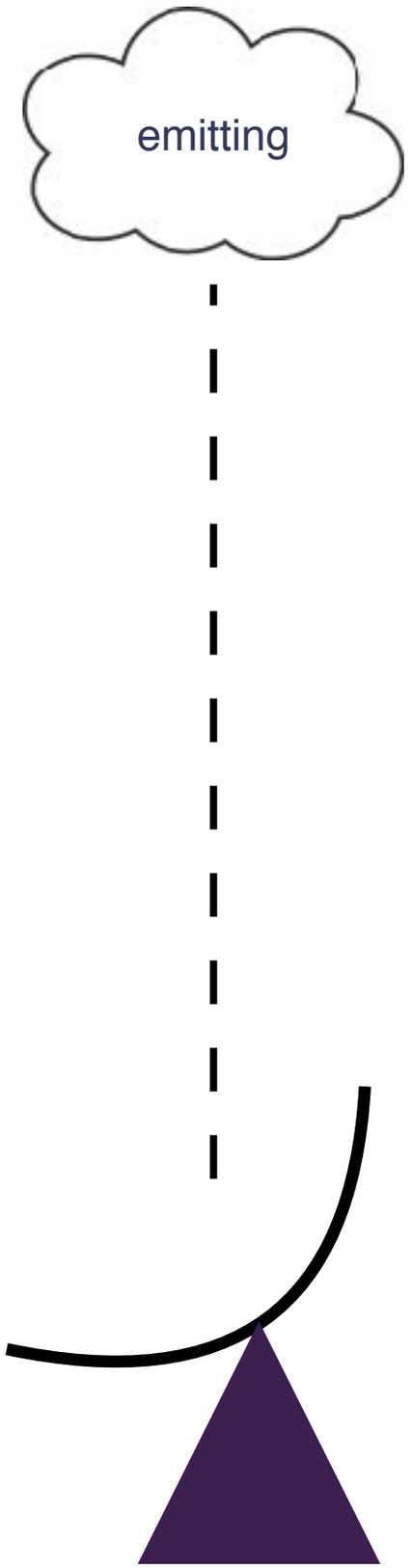


Image plane



Q-U plane



$$P = \sqrt{Q^2 + U^2} \qquad \theta = \frac{1}{2}\tan^{-1}\left(\frac{Q}{U}\right)$$

Q-U Invariance: Polarization Gradient

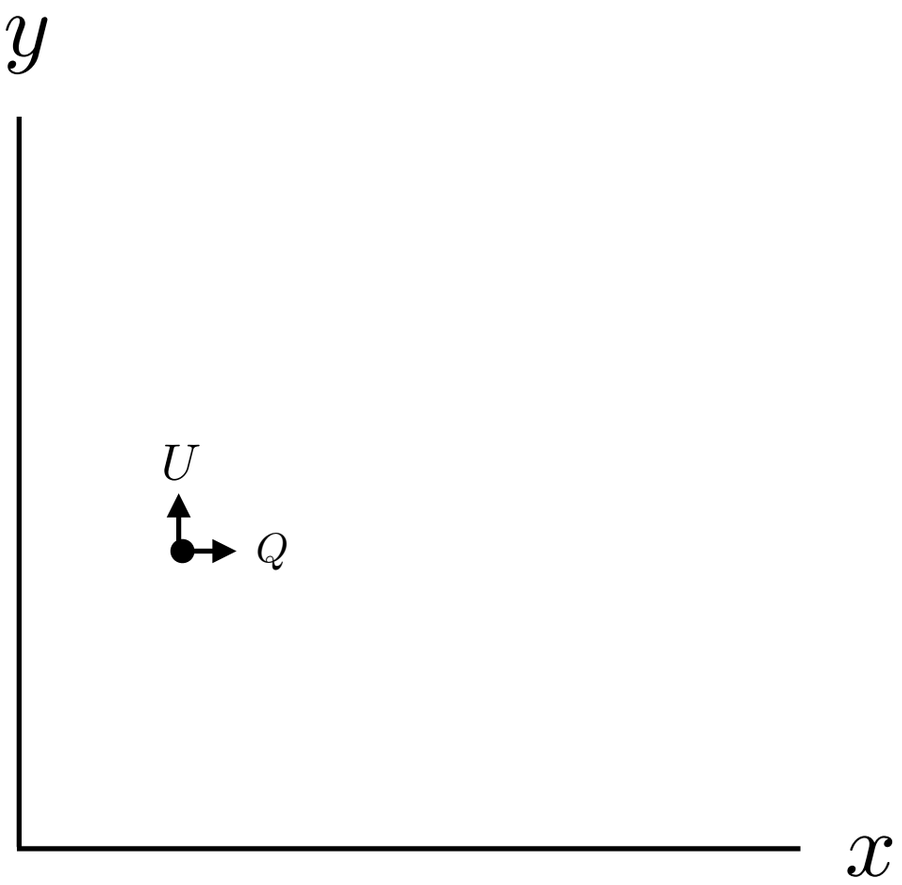
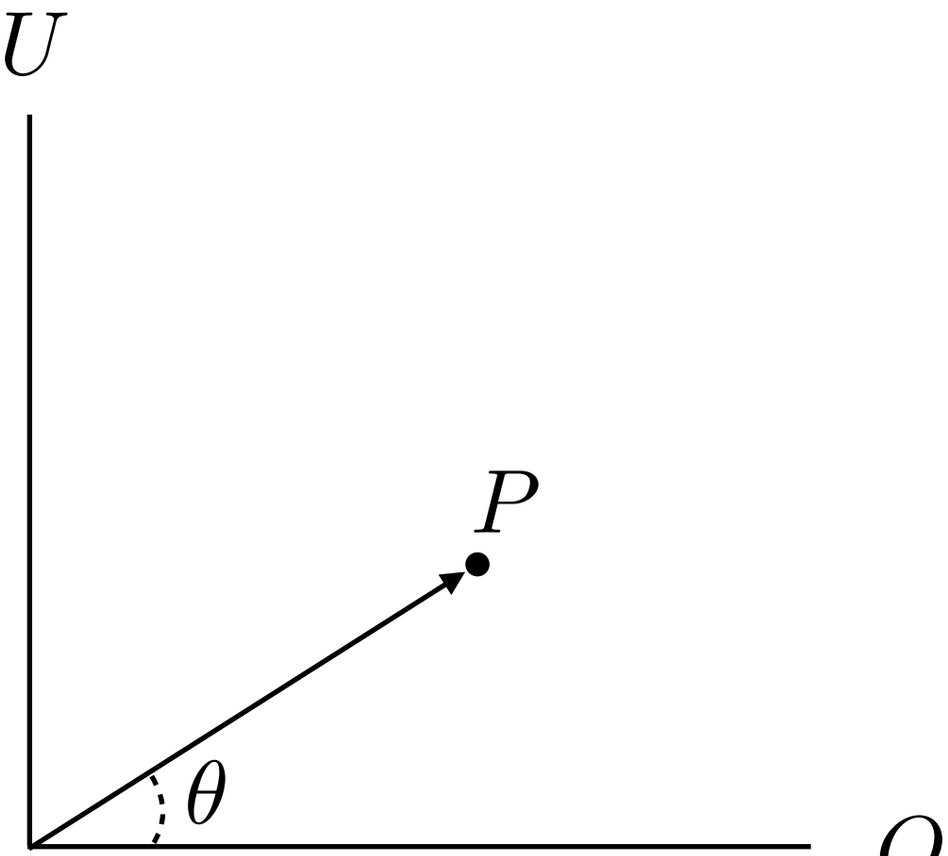
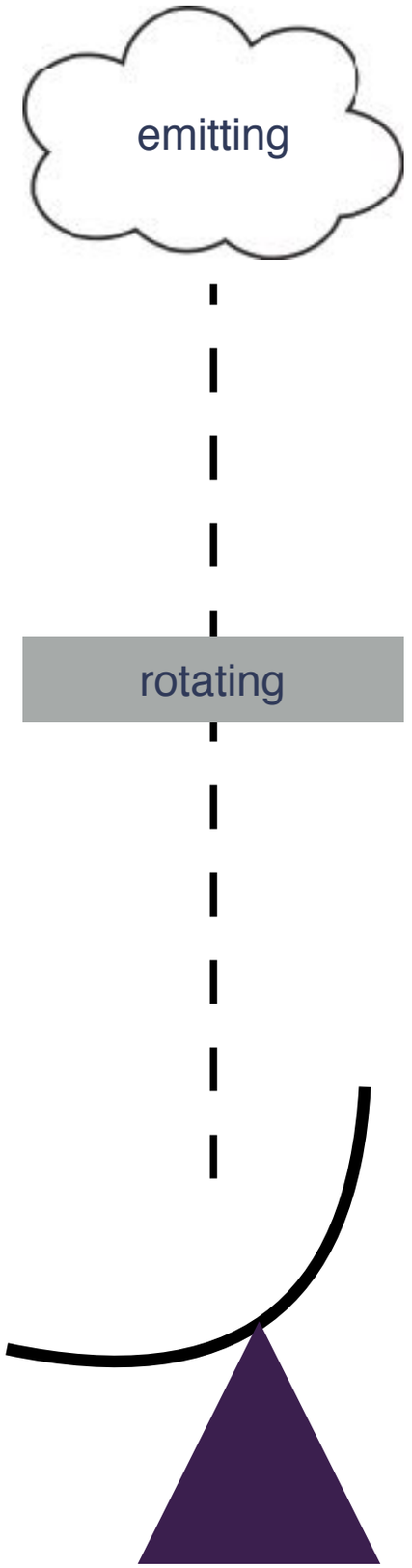


Image plane



Q-U plane



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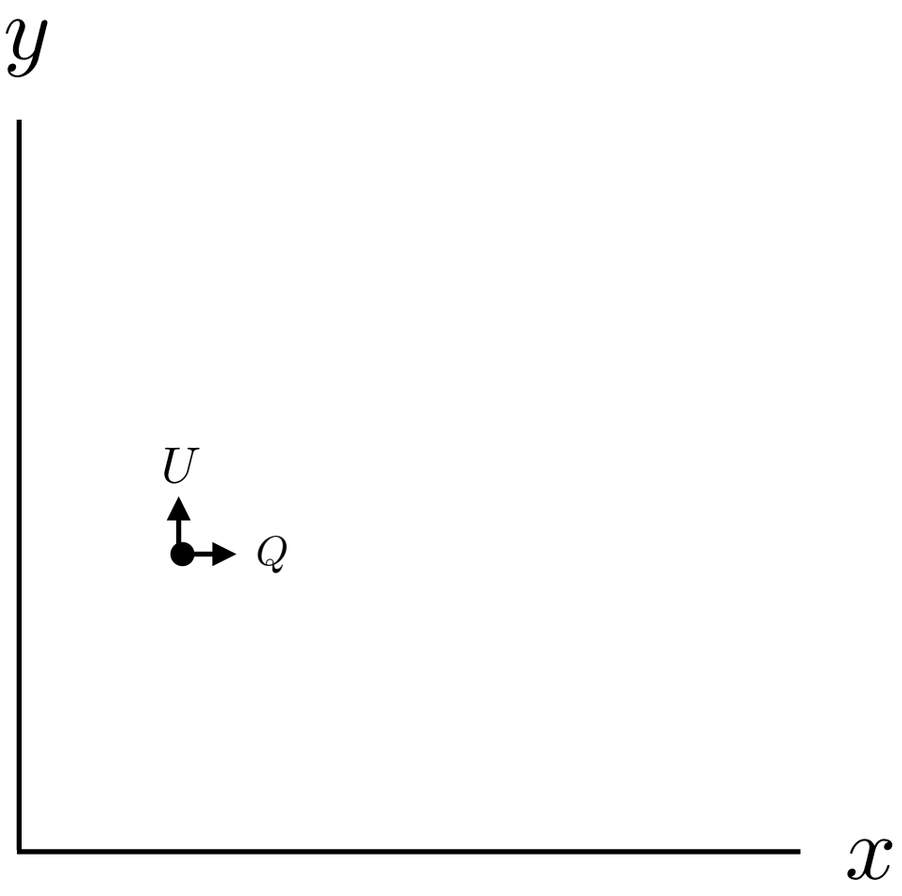
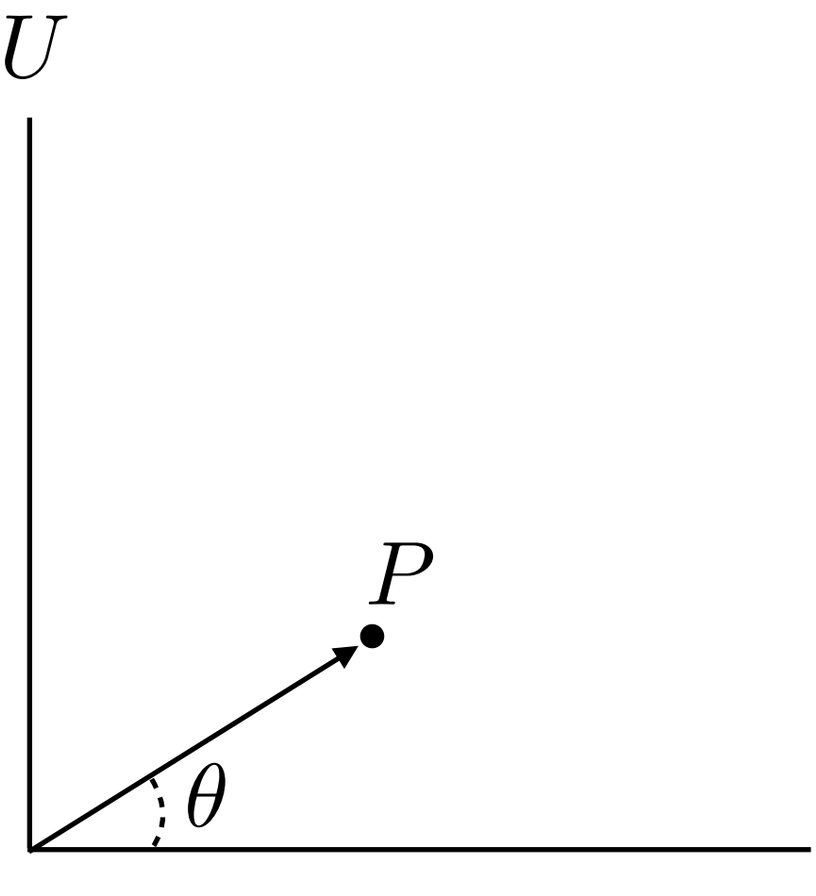
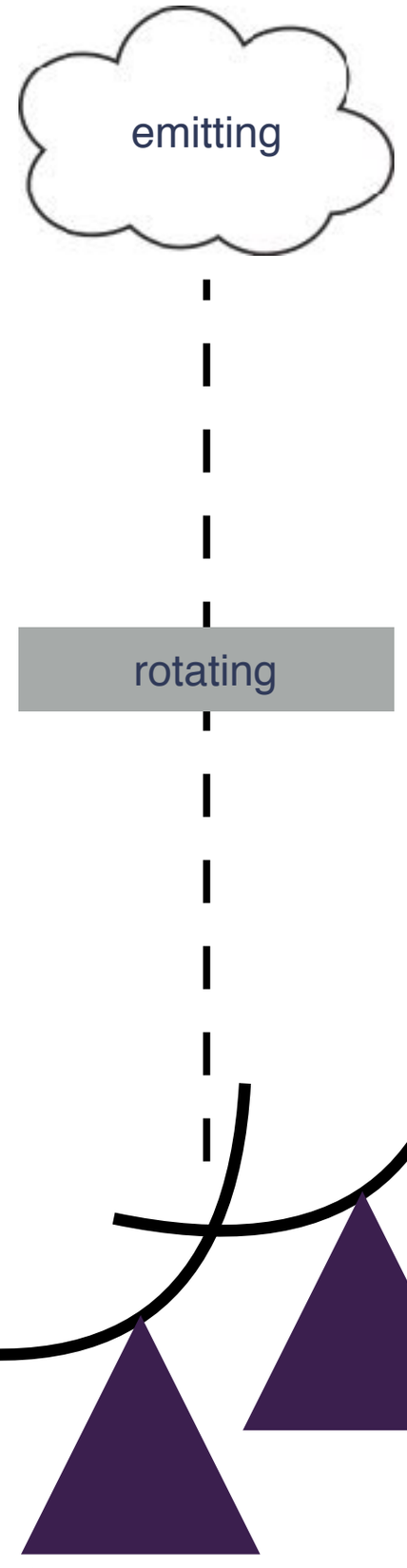


Image plane



Q-U plane



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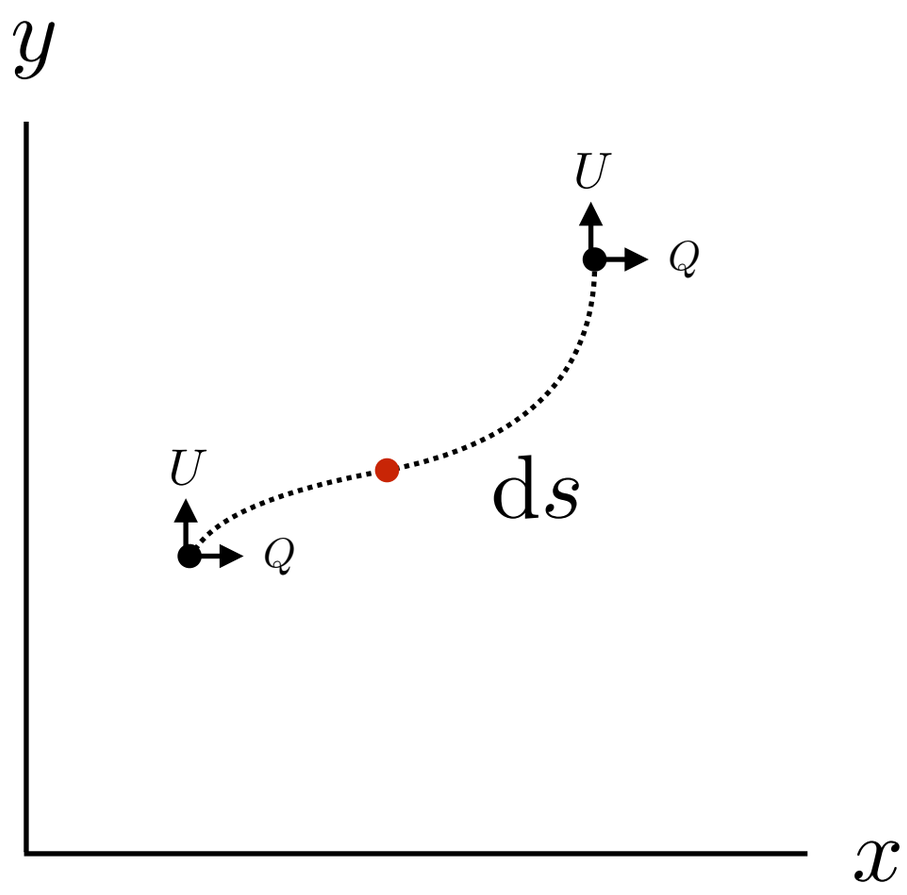
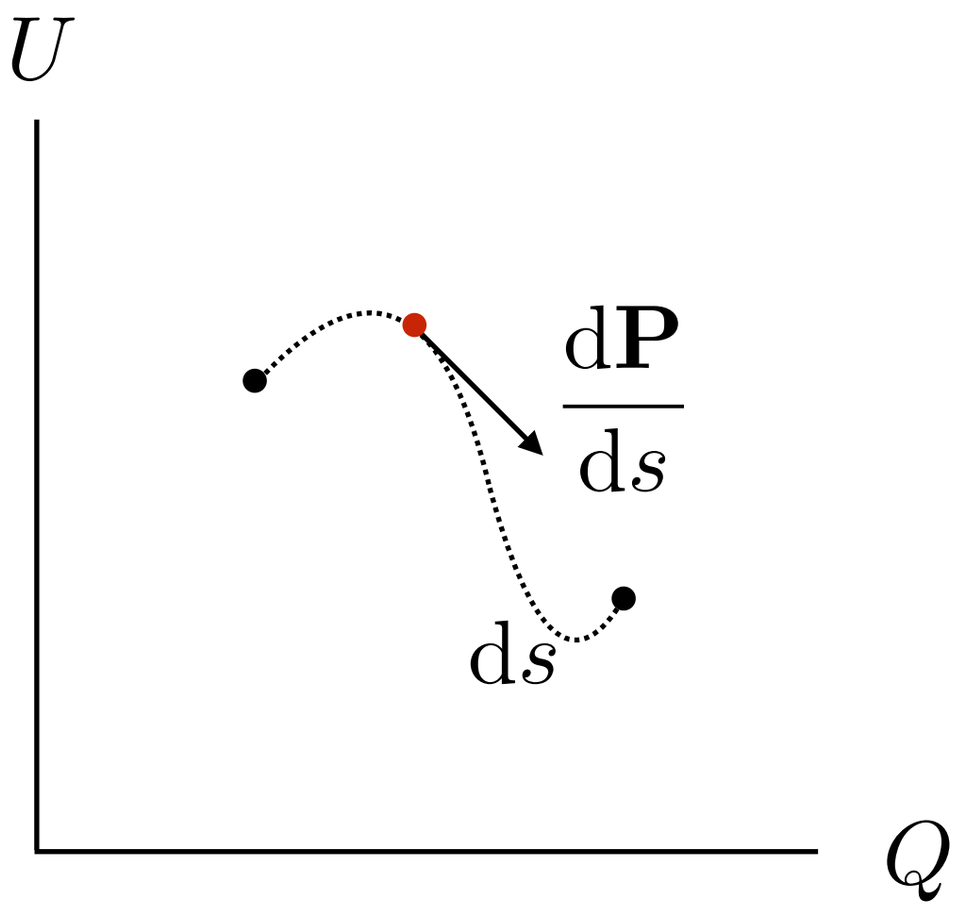


Image plane



Q-U plane

$$|\nabla P| = \sqrt{\left(\frac{\partial Q}{\partial x}\right)^2 + \left(\frac{\partial U}{\partial x}\right)^2 + \left(\frac{\partial Q}{\partial y}\right)^2 + \left(\frac{\partial U}{\partial y}\right)^2}$$

Gaensler et al., 2011

Q-U Invariance: Polarization Gradient Decomposition

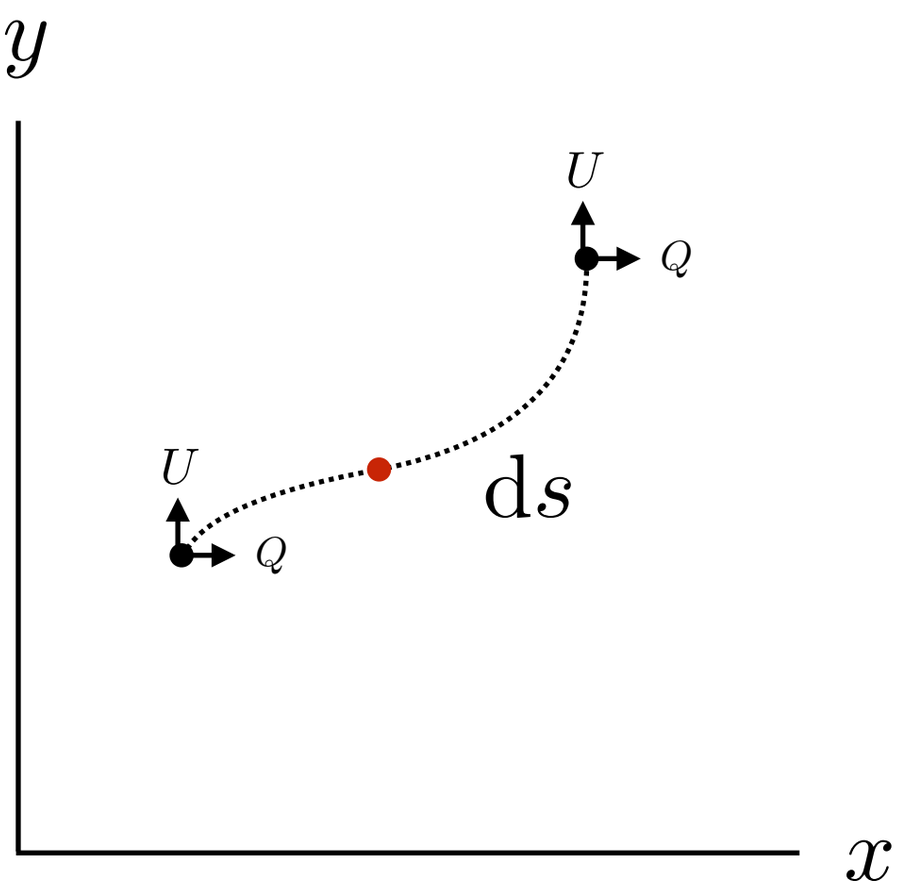
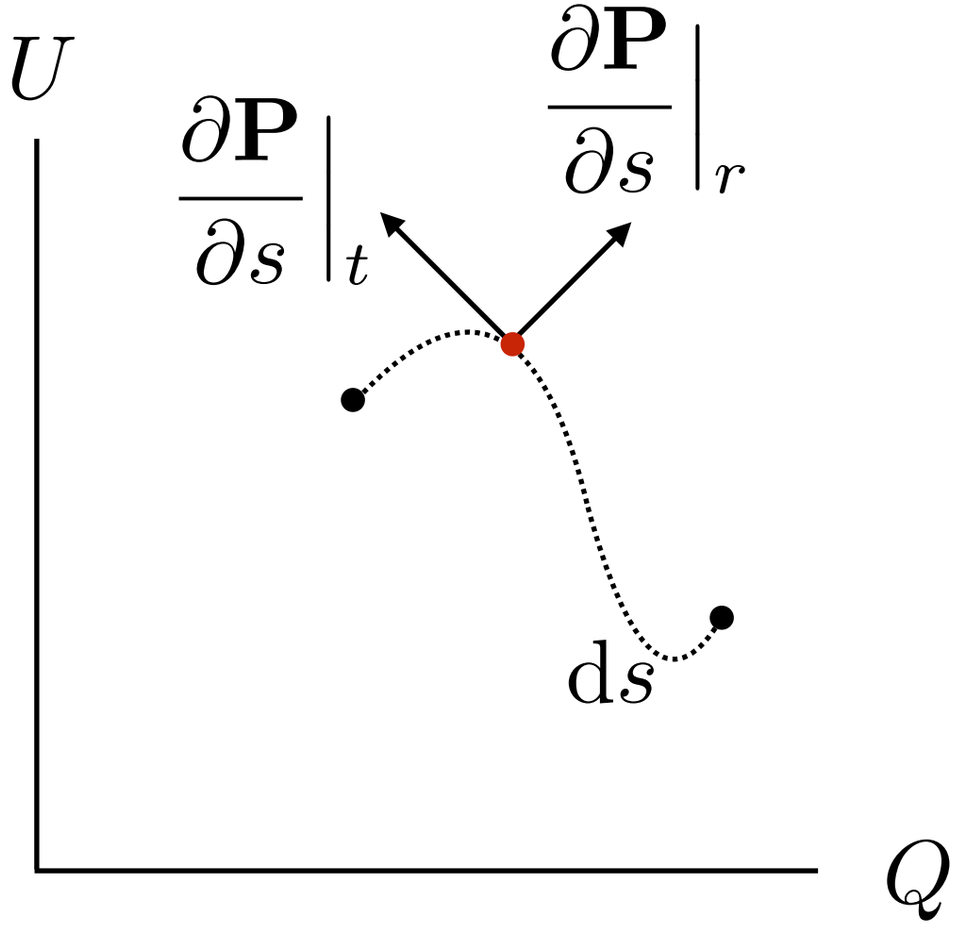


Image plane



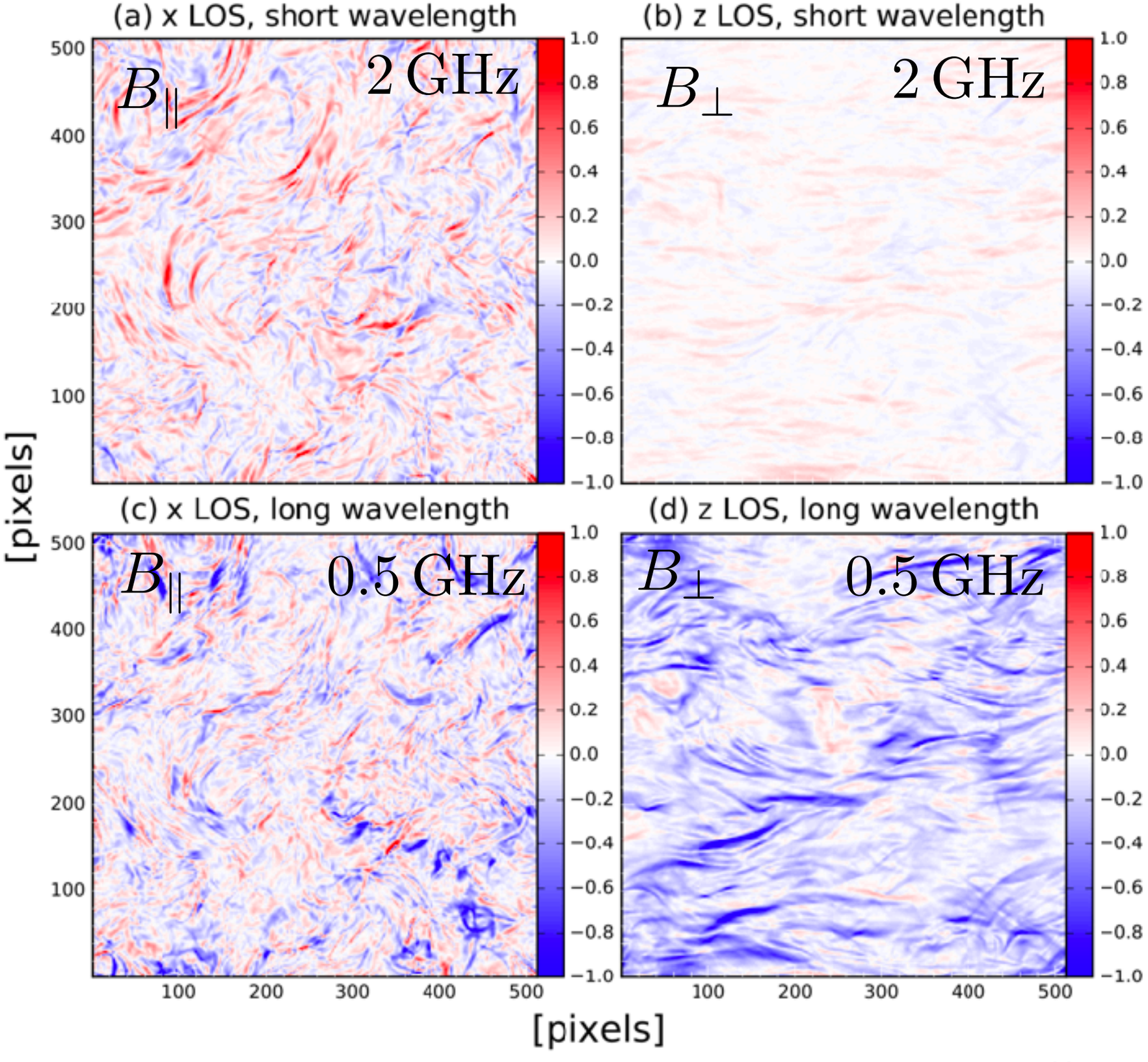
Q-U plane

Herron et al., 2018

$$\frac{\partial \mathbf{P}}{\partial s}_{\text{rad}} = \sqrt{\frac{(Q\frac{\partial Q}{\partial x} + U\frac{\partial U}{\partial x})^2 + (Q\frac{\partial Q}{\partial y} + U\frac{\partial U}{\partial y})^2}{Q^2 + U^2}}$$

$$\frac{\partial \mathbf{P}}{\partial s}_{\text{tangential}} = \sqrt{\frac{(Q\frac{\partial U}{\partial x} - U\frac{\partial Q}{\partial x})^2 + (Q\frac{\partial U}{\partial y} - U\frac{\partial Q}{\partial y})^2}{Q^2 + U^2}}$$

Q-U Invariance: Polarization Gradient Decomposition



red: $\left.\frac{\partial \mathbf{P}}{\partial s}\right|_r$

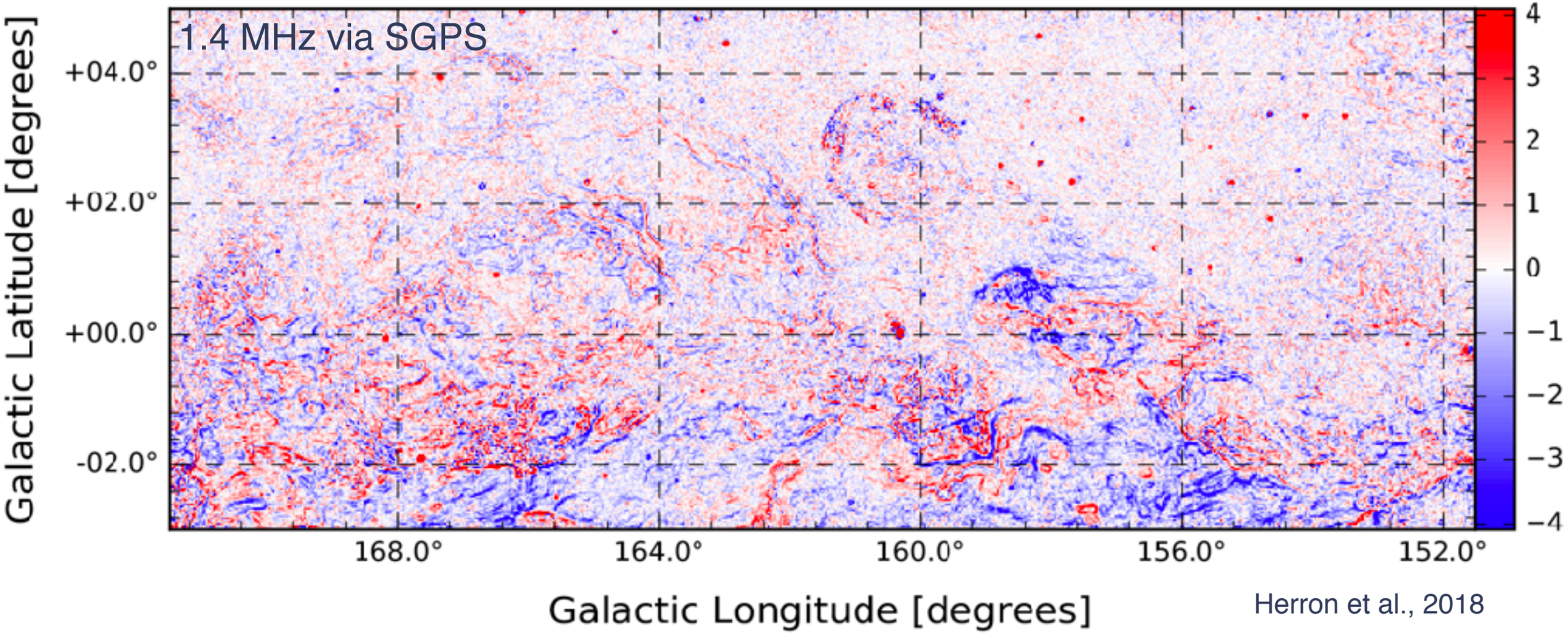
blue: $\left.\frac{\partial \mathbf{P}}{\partial s}\right|_t$

$$M_s = \left\langle \frac{|v|}{c_s} \right\rangle = 0.5$$

$$M_a = \left\langle \frac{|v|}{v_a} \right\rangle = 0.7$$

Herron et al., 2018

Q-U Invariance: Polarization Gradient Decomposition

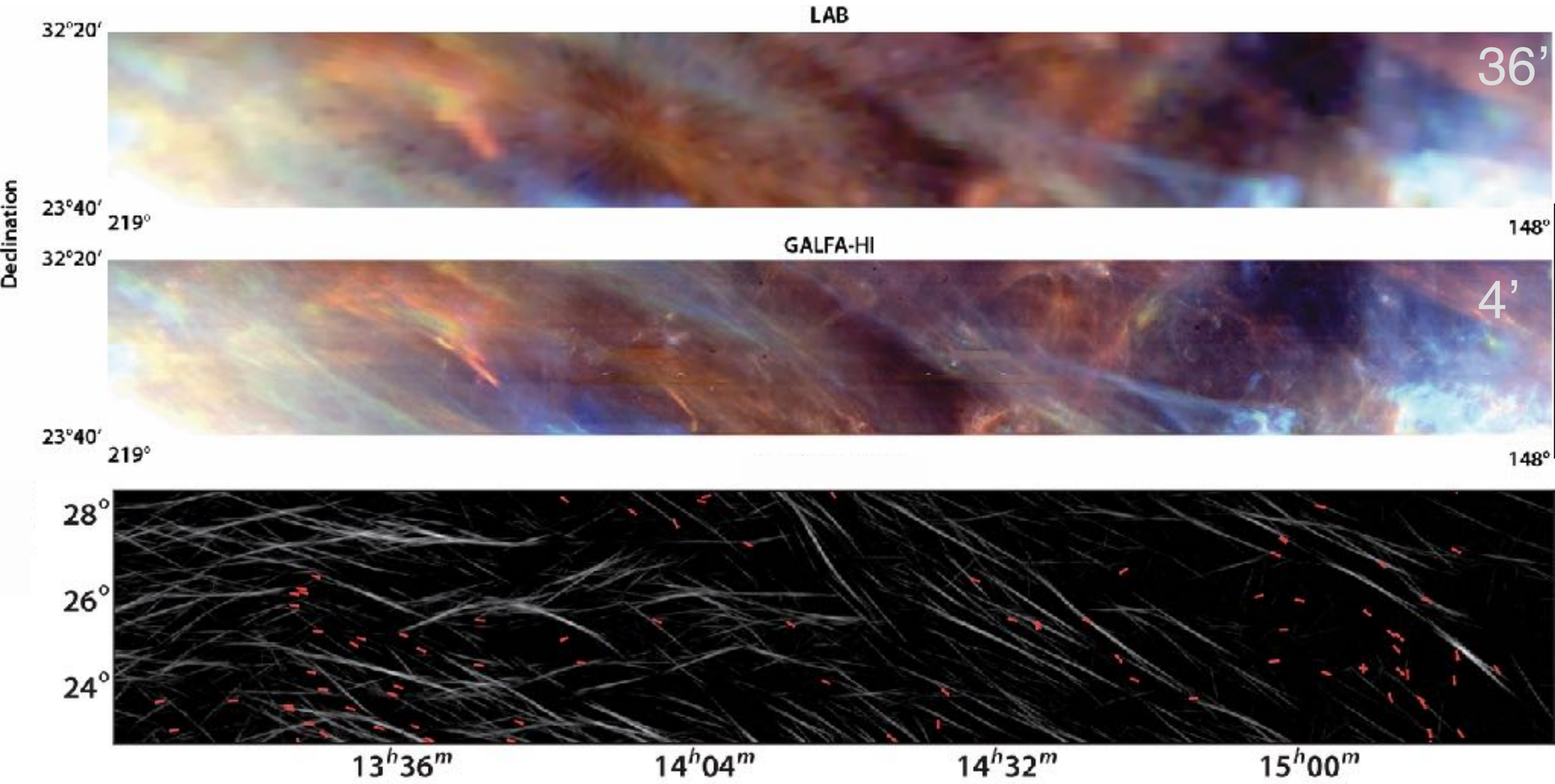


Herron et al., 2018

red: radial component (changes in polarization intensity) dominated

blue: tangential component (changes in polarization angle) dominated

More diffuse structure — Magnetically aligned 21 cm HI fibers



Clark et al., 2014

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