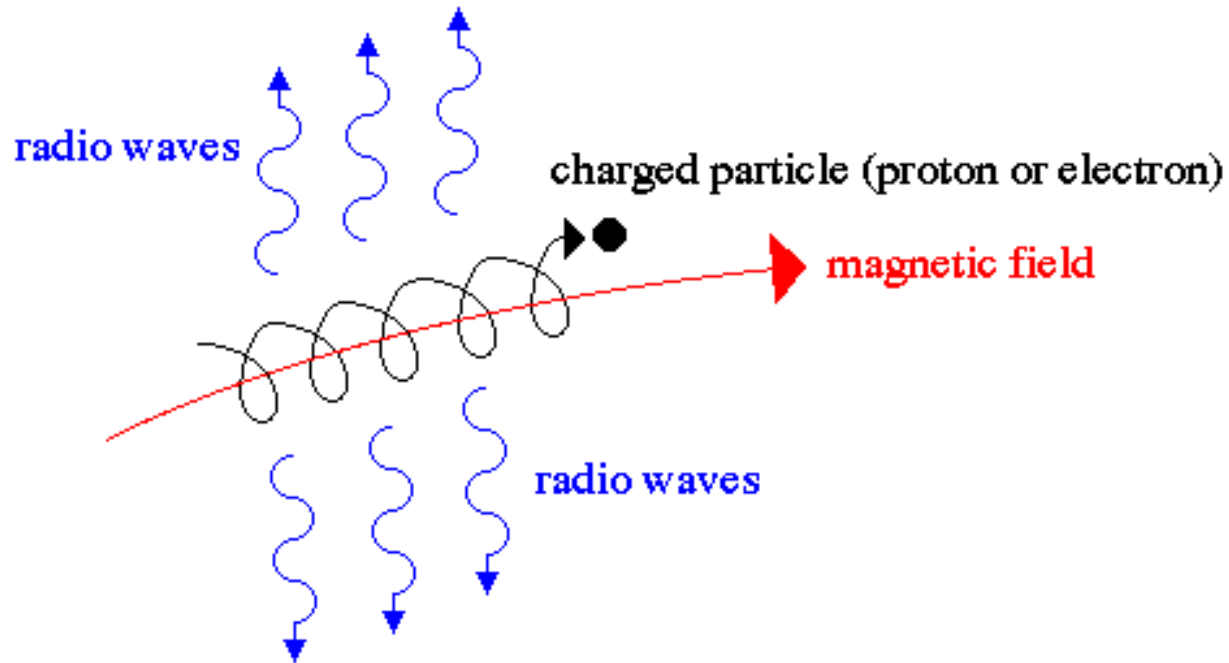


Istraživanje zvjezdanih tragova u međuzvjezdanom prostoru

Autor: Domagoj Božan

Mentor: dr. sc. Lovro Palaversa

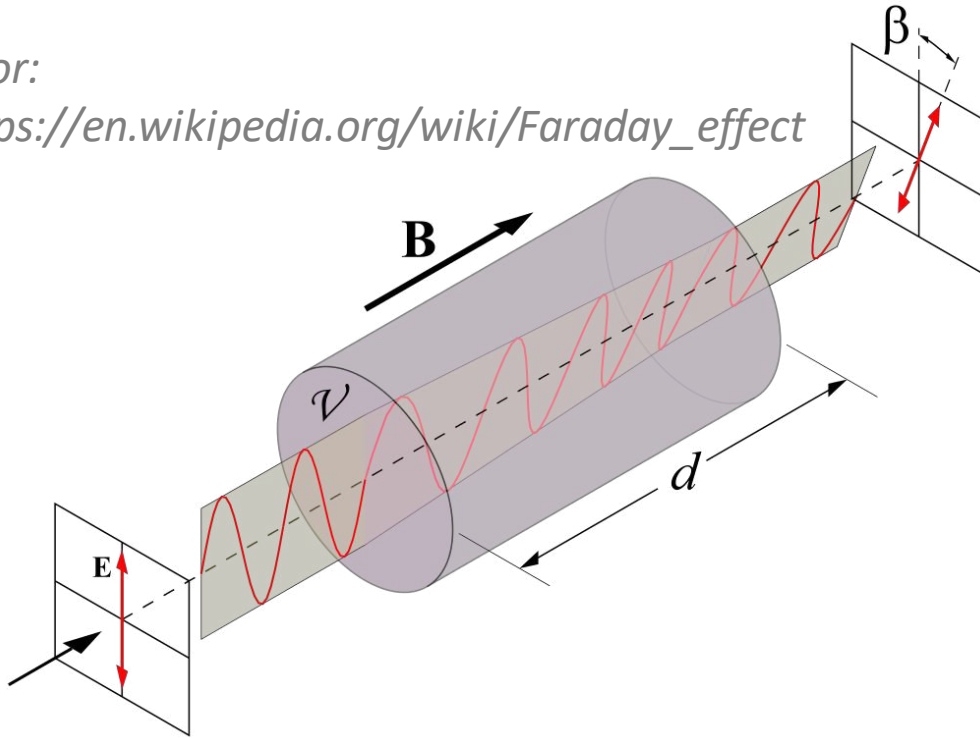
Galaktičko sinkrotronsko zračenje



Faradayeva rotacija

Izvor:

https://en.wikipedia.org/wiki/Faraday_effect

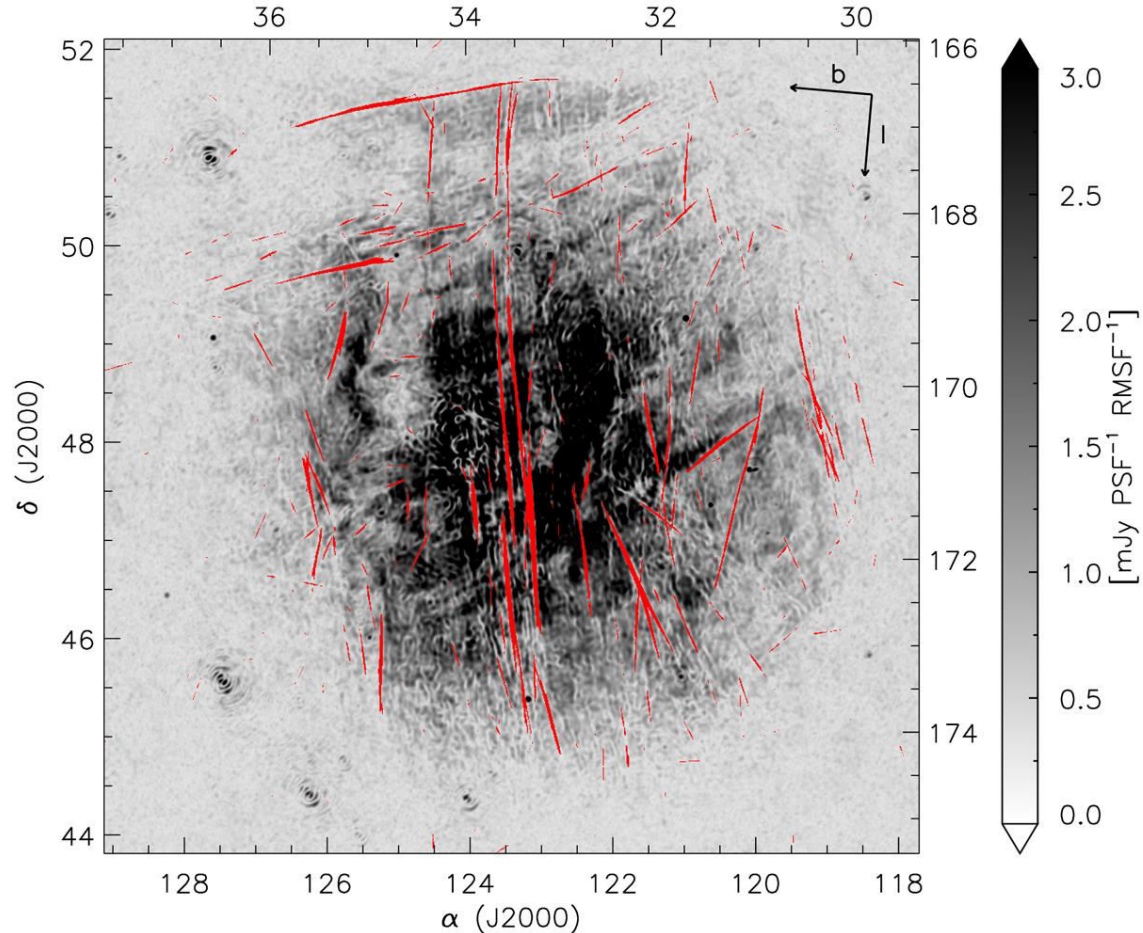


- zakretanje ravnine polarizacije sinkrotronskog zračenja
- nastaje međudjelovanjem sinkrotronskog zračenja s međuzvezdanom tvari uz prisustvo magnetskog polja

$$\Phi [\text{rad} / m^2] = 0.81 [\text{rad} / m^2] \int_{\text{izvor}}^{\text{promatrač}} \frac{n_e}{[cm^{-3}]} \frac{B_{\parallel}}{[\mu G]} \frac{dl}{[pc]}$$

Depolarizirani kanali

- promatranjem Faradayeve rotacije uočene su duge i ravne vlaknaste strukture unutar kojih je zračenje depolarizirano
- način nastanka još nije sasvim razjašnjen → moguć uzrok ionizirajući tragovi zvijezda



Izvor: V. Jelić, D. Prelogović, M. Haverkorn, et al. 2018, A&A, 615, L3

Radioteleskop LOFAR

- LOw Frequency ARray (10 – 250 MHz)
- interferometar



Izvor: <https://www.irb.hr/>

Radioteleskop LOFAR



Low Band Antenna: 10 – 80
MHz

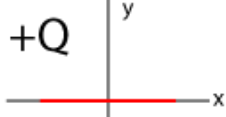

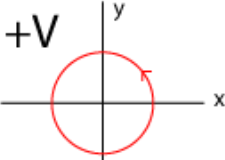
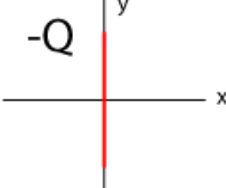
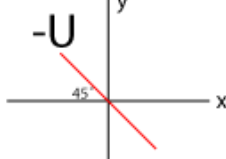
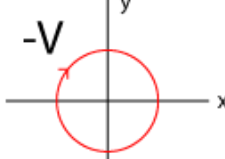
Izvor: <https://en.wikipedia.org/wiki/LOFAR>

High Band Antenna: 100 –
250 MHz

Izvor: blog.lofar-uk.org



Stokesovi parametri

100% Q	100% U	100% V
<p>+Q</p>  <p>$Q > 0; U = 0; V = 0$ (a)</p>	<p>+U</p>  <p>$Q = 0; U > 0; V = 0$ (c)</p>	<p>+V</p>  <p>$Q = 0; U = 0; V > 0$ (e)</p>
<p>-Q</p>  <p>$Q < 0; U = 0; V = 0$ (b)</p>	<p>-U</p>  <p>$Q = 0; U < 0; V = 0$ (d)</p>	<p>-V</p>  <p>$Q = 0; U = 0; V < 0$ (f)</p>

- Stokes I \rightarrow ukupno zračenje
- Stokes Q, U \rightarrow linearno polarizirano zračenje
- Stokes V \rightarrow cirkularno polarizirano zračenje
- P \rightarrow ukupno polarizirano zračenje

$$I^2 \geq Q^2 + U^2 + V^2 = P^2$$

Izvor:

https://en.wikipedia.org/wiki/Stokes_parameters

Rotation Measure sinteza

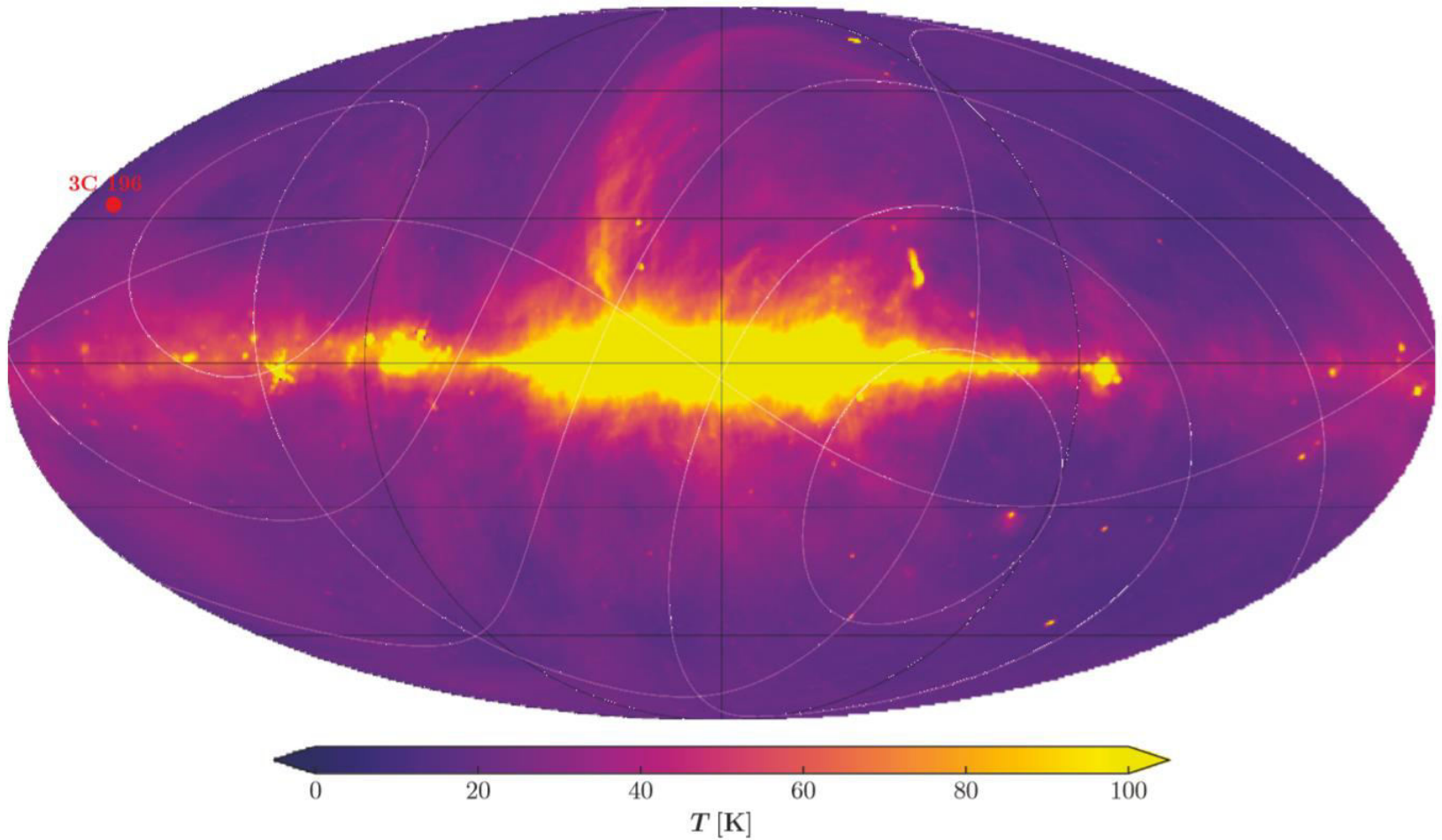
- radioteleskop mjeri zračenje u Stokes parametrima I, Q, U, V na različitim frekvencijama

$$P(\lambda^2) = Q(\lambda^2) + iU(\lambda^2)$$

- RM sinteza \rightarrow transformacija iz λ^2 prostora u prostor Faradayeve dubine ϕ

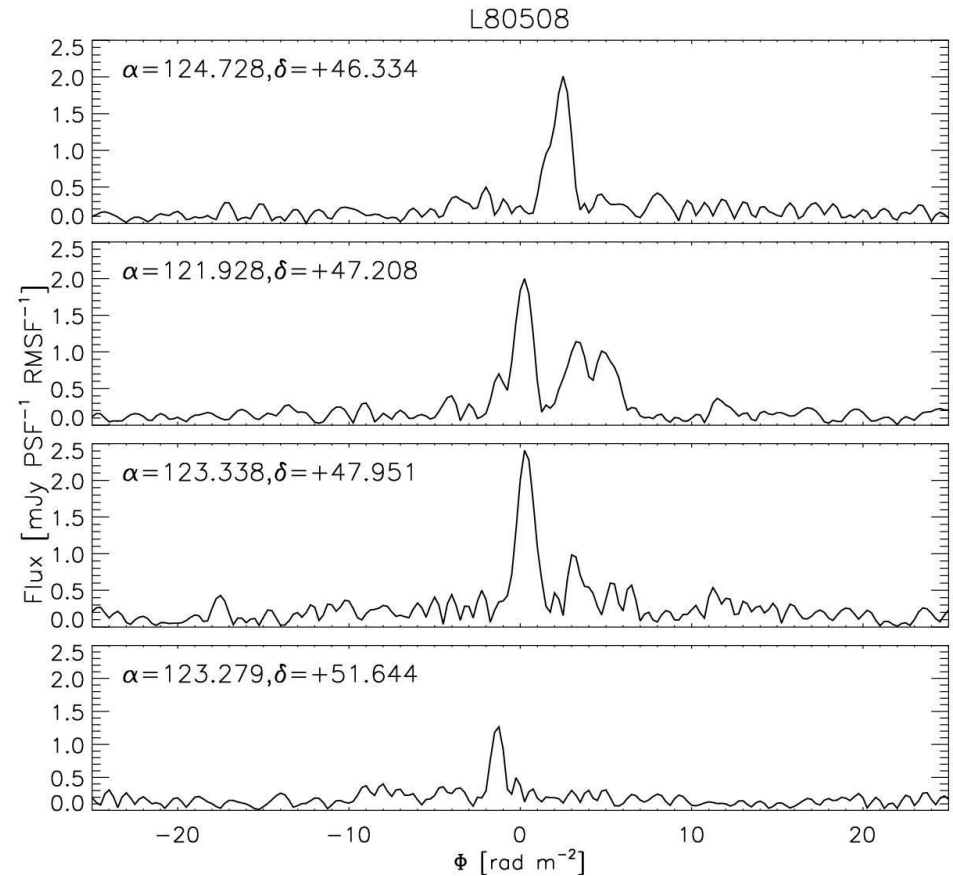
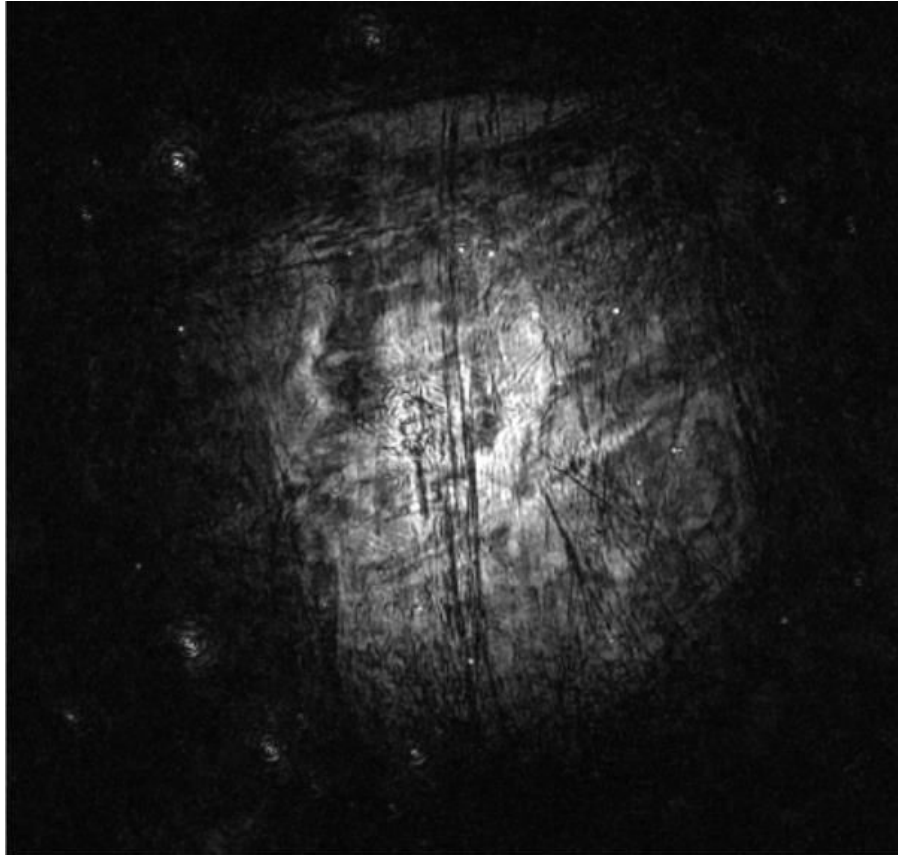
$$F(\Phi) = \frac{1}{W(\lambda^2)} \int_{-\infty}^{+\infty} P(\lambda^2) e^{-i2\Phi\lambda^2} d\lambda^2$$

Polje 3C196

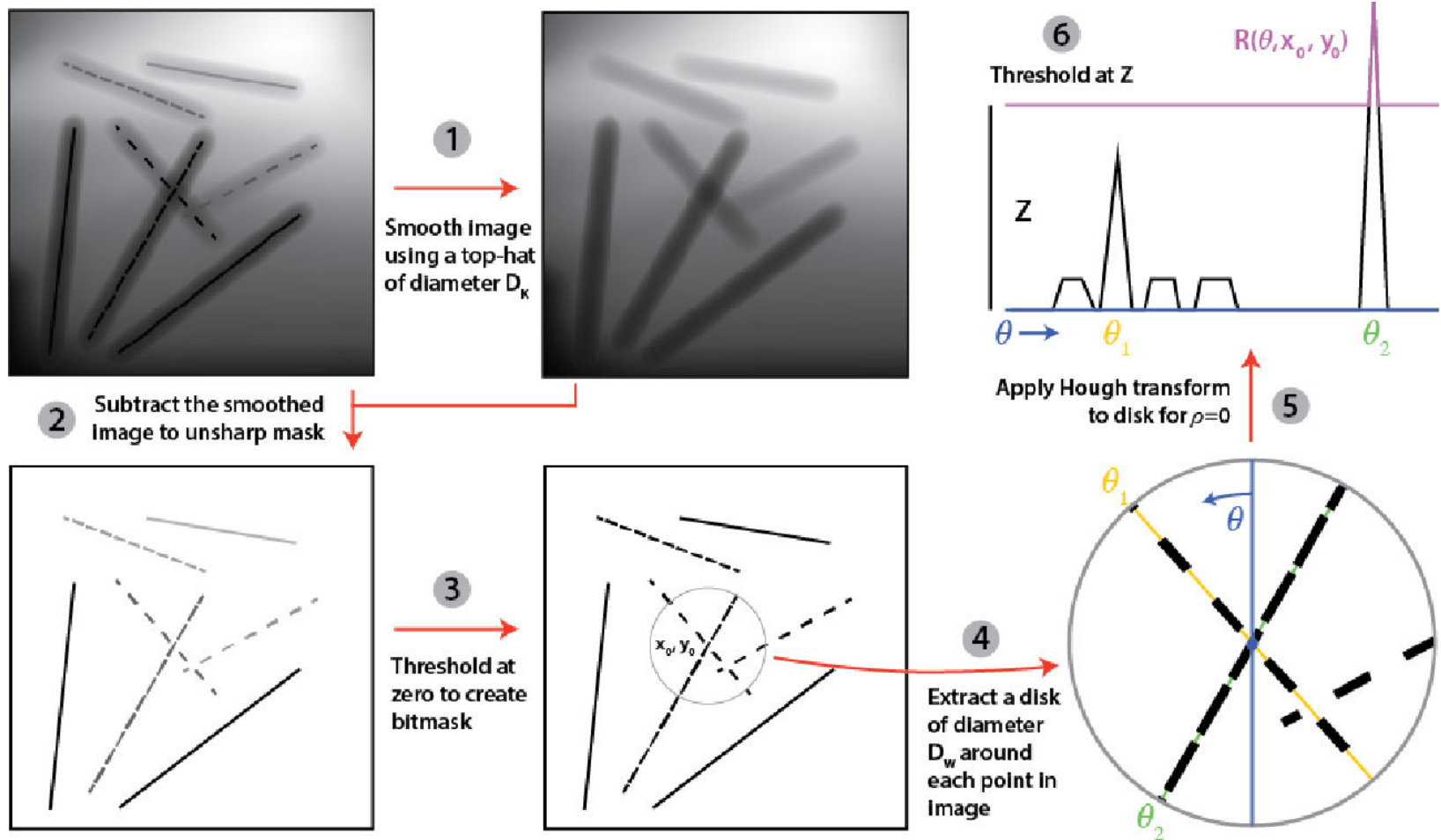


Izvor: <https://lambda.gsfc.nasa.gov/>

Polje 3C196 – maksimum intenziteta



RHT – Rolling Hough Transform



RHT – Rolling Hough Transform



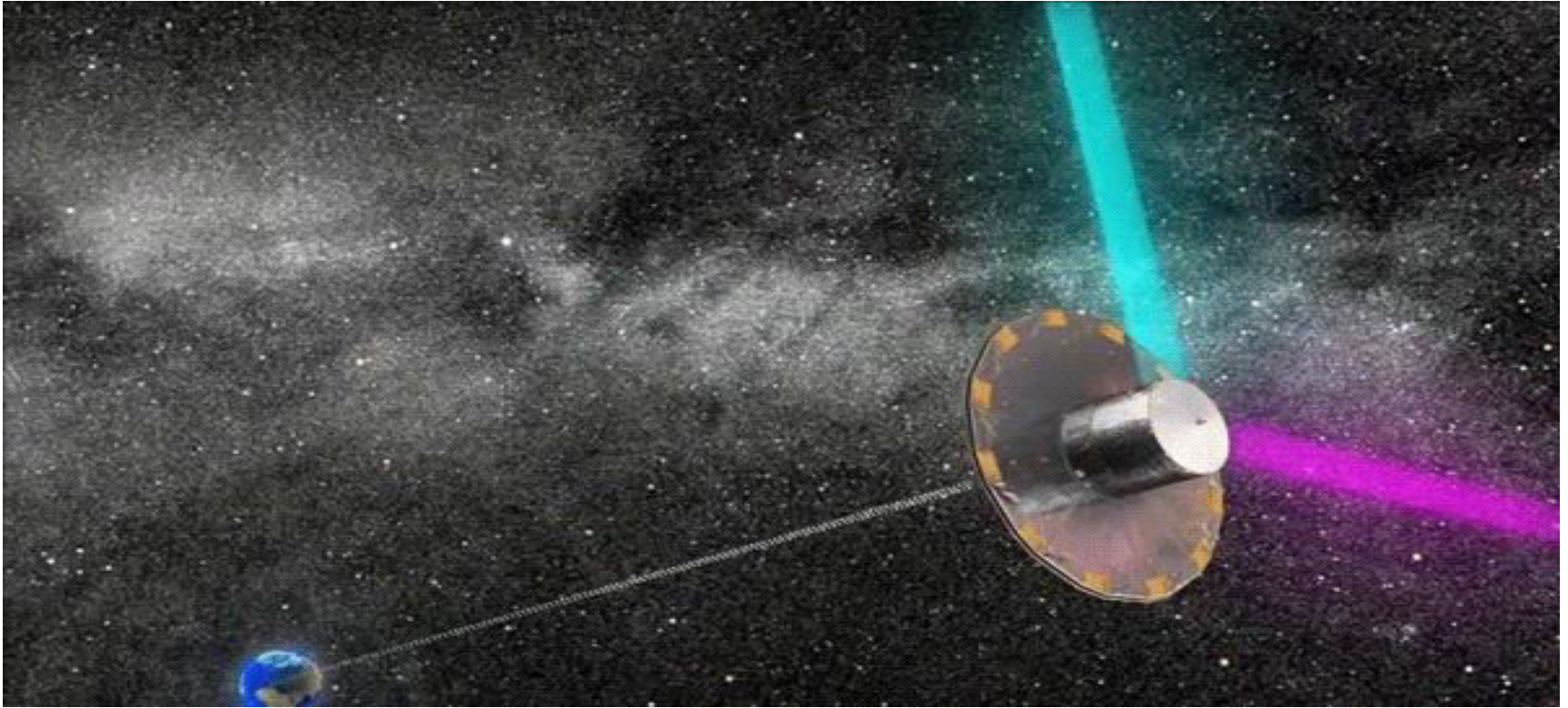
- algoritam osmišljen za nalaženje linearnih struktura na slici
- integracijom po cijeloj slici dobiva se informacija o orijentaciji ravnih linija

$$\tilde{R}(\theta) = \frac{1}{N} \iint R(\theta, x, y) dx dy$$

- moguće je kvantificirati zvijezde s obzirom na to koliko dobro prolaze linearnim strukturama

$$M_* = \int_{t_{in}}^{t_{out}} R(\theta_r(t), r_{xy}(t)) dt$$

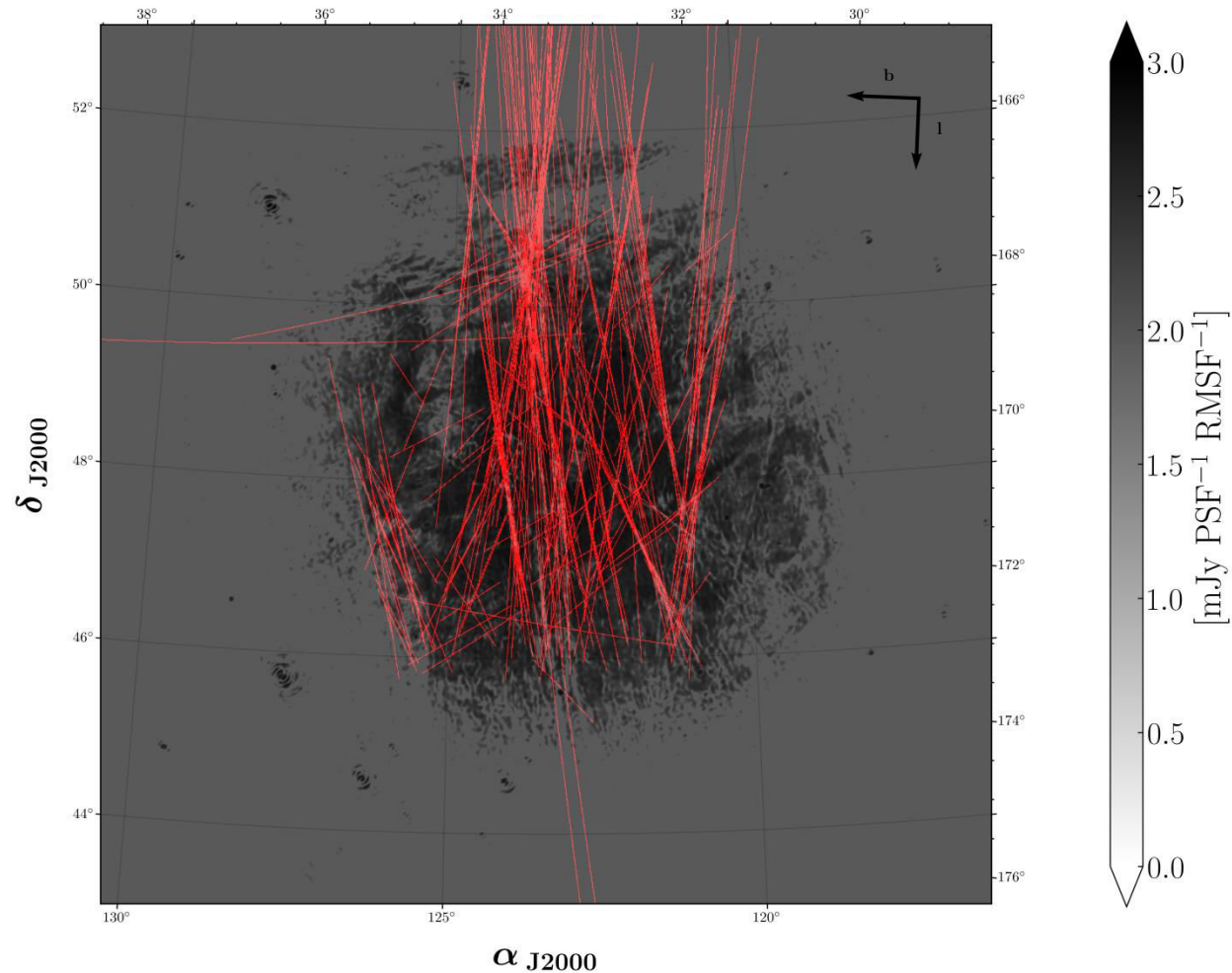
Satelit Gaia



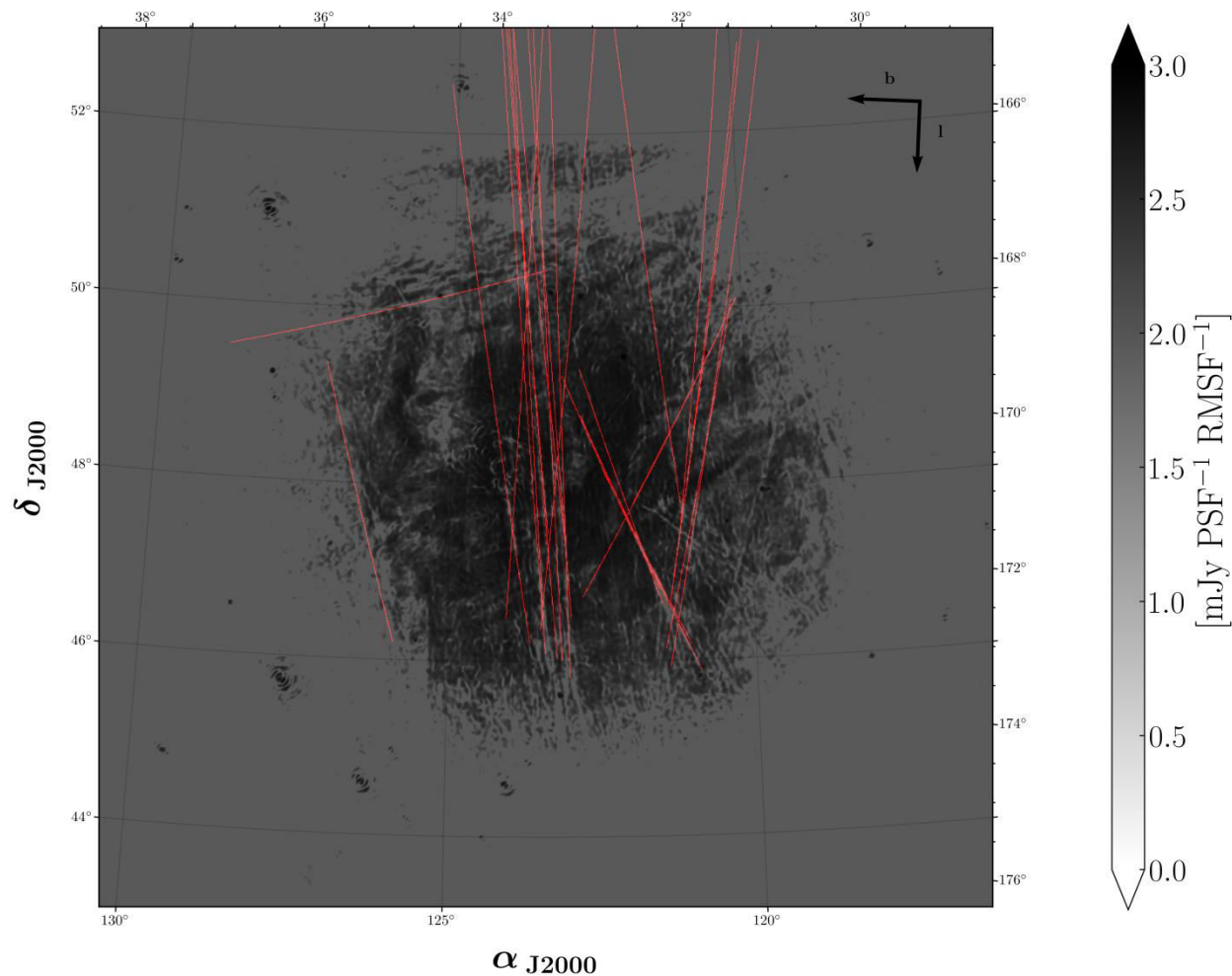
Izvor: <https://www.nature.com/>

- Određen položaj 1.7 milijardi zvijezda te vlastito gibanje za 1.3 milijarde zvijezda

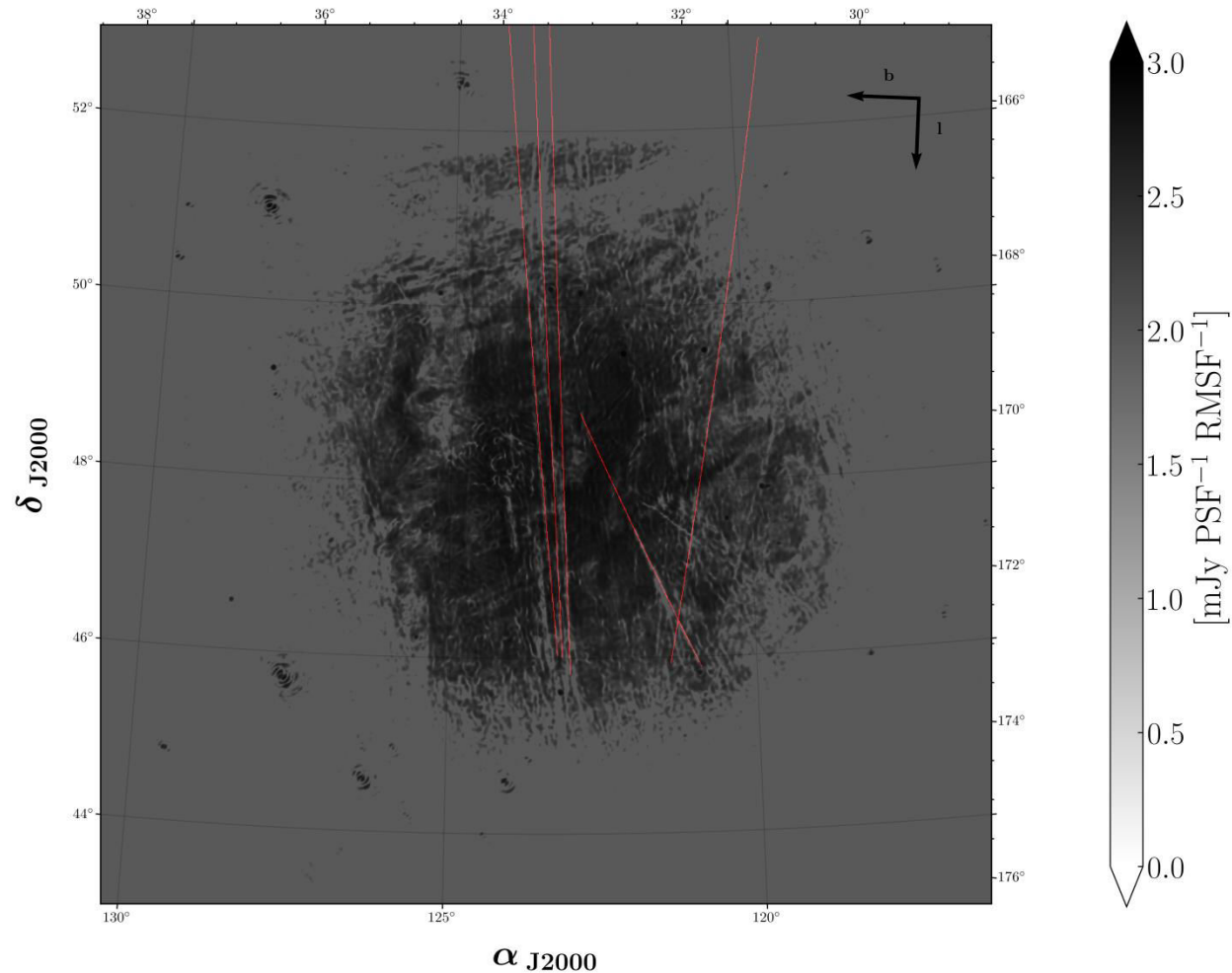
Rezultati – putanje zvijezda na slici dulje od 50 piksela



Rezultati – putanje zvijezda na slici dulje od 100 piksela



Rezultati – putanje zvijezda na slici dulje od 150 piksela



Zaključci

- Uočene su putanje zvijezda koje se poklapaju s položajima depolariziranih kanala.
- Međutim, zbog velikog broja zvijezda u polju, vjerojatno je da će eventualno neke zvijezde proći kroz područja depolariziranih kanala.
- Potrebno je daljnje istraživanje kako bi se zasigurno utvrdilo nastaju li depolarizirani kanali zbog interakcije zvijezda s međuzvjezdanom tvari.

Literatura

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- <http://ds9.si.edu/site/Home.html>
- <https://gea.esac.esa.int/archive/>
- <https://www.cosmos.esa.int/web/gaia/the-mission>
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- V. Jelić, D. Prelogović, M. Haverkorn, et al. 2018, A&A, 615, L3
- V. Jelić, A.G. de Bruyn, V.N. Pandey, et al. 2015, A&A, 583, A137
- M. Brentjens & A.G. de Bruyn, 2005, A&A, 441, 1217

Dodatak – filtriranje Gaia podataka

