Fun with Cyclic Spectroscopy

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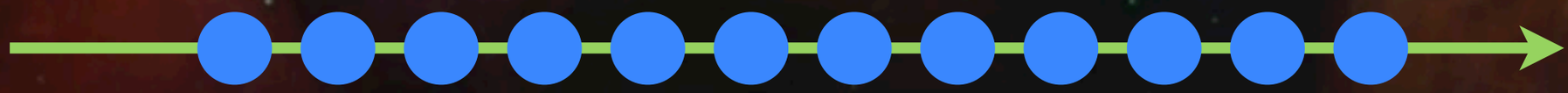
Overview

- What is cyclic spectroscopy ?
- Extracting information from cyclic spectra
- Holographic imaging
- Anticipated developments

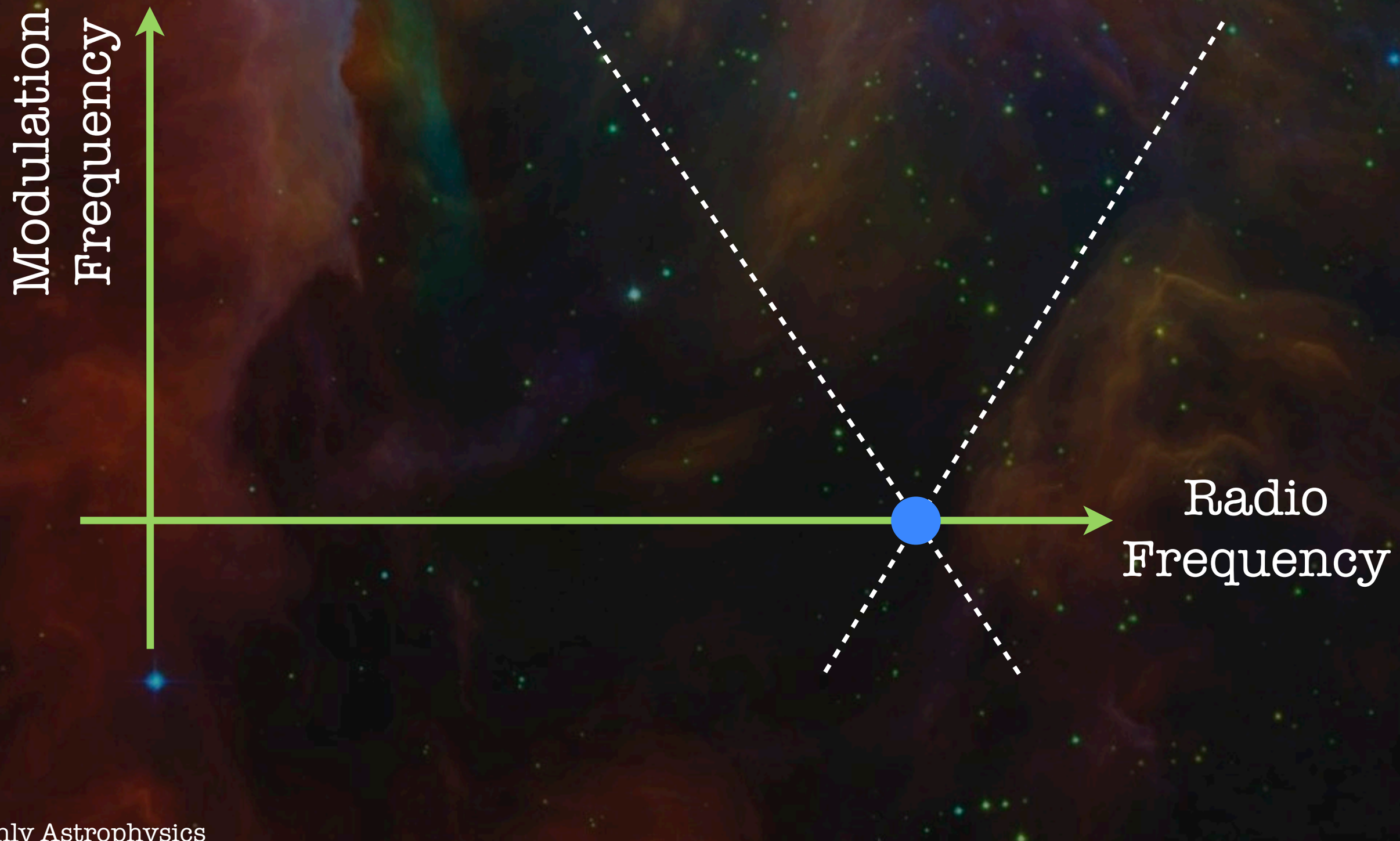
Spectroscopy



Radio Frequency

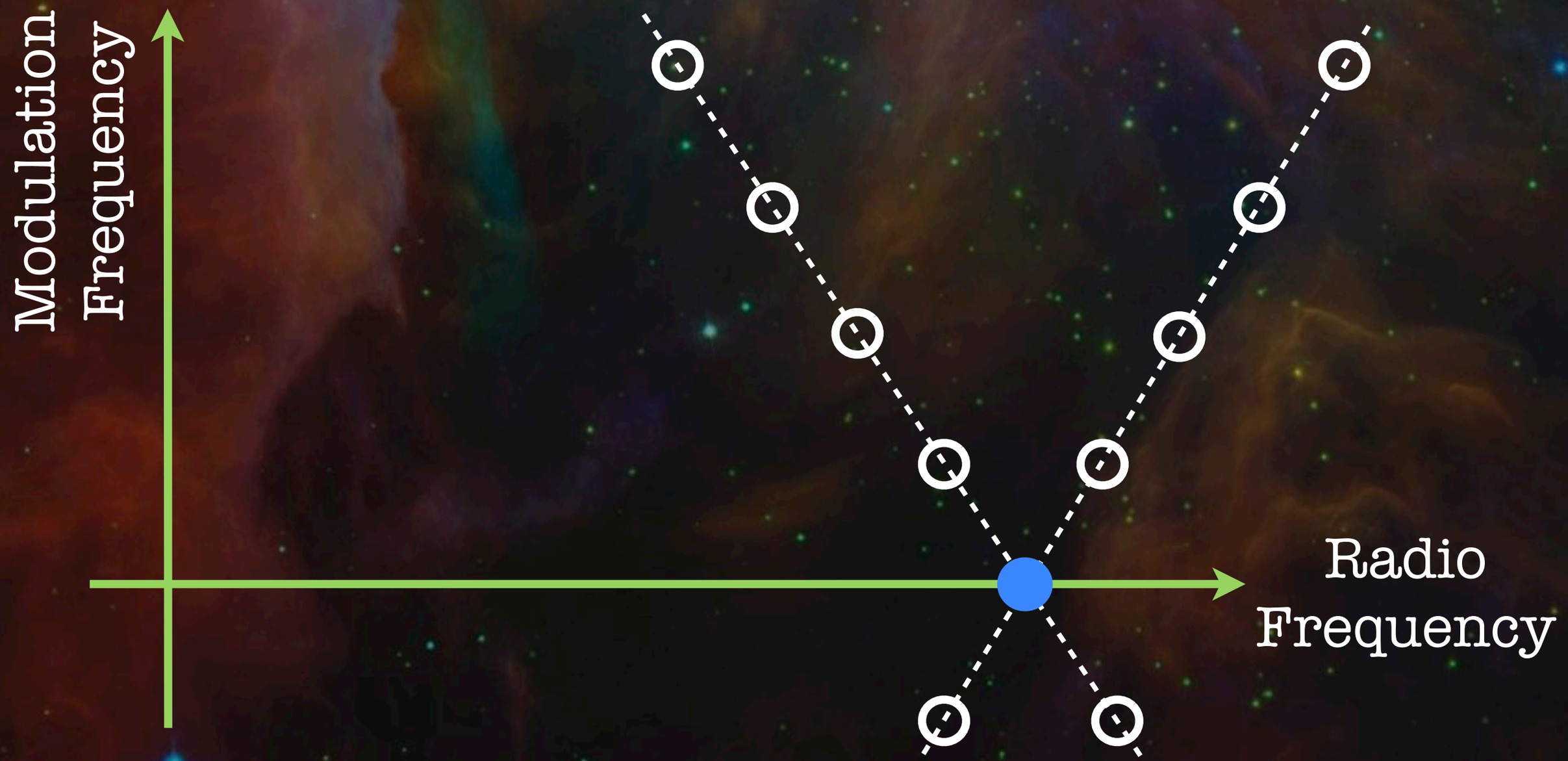
Cyclic Spectroscopy

Demorest 2011, MNRAS



Cyclic Spectroscopy

Demorest 2011, MNRAS



Cyclic Spectroscopy

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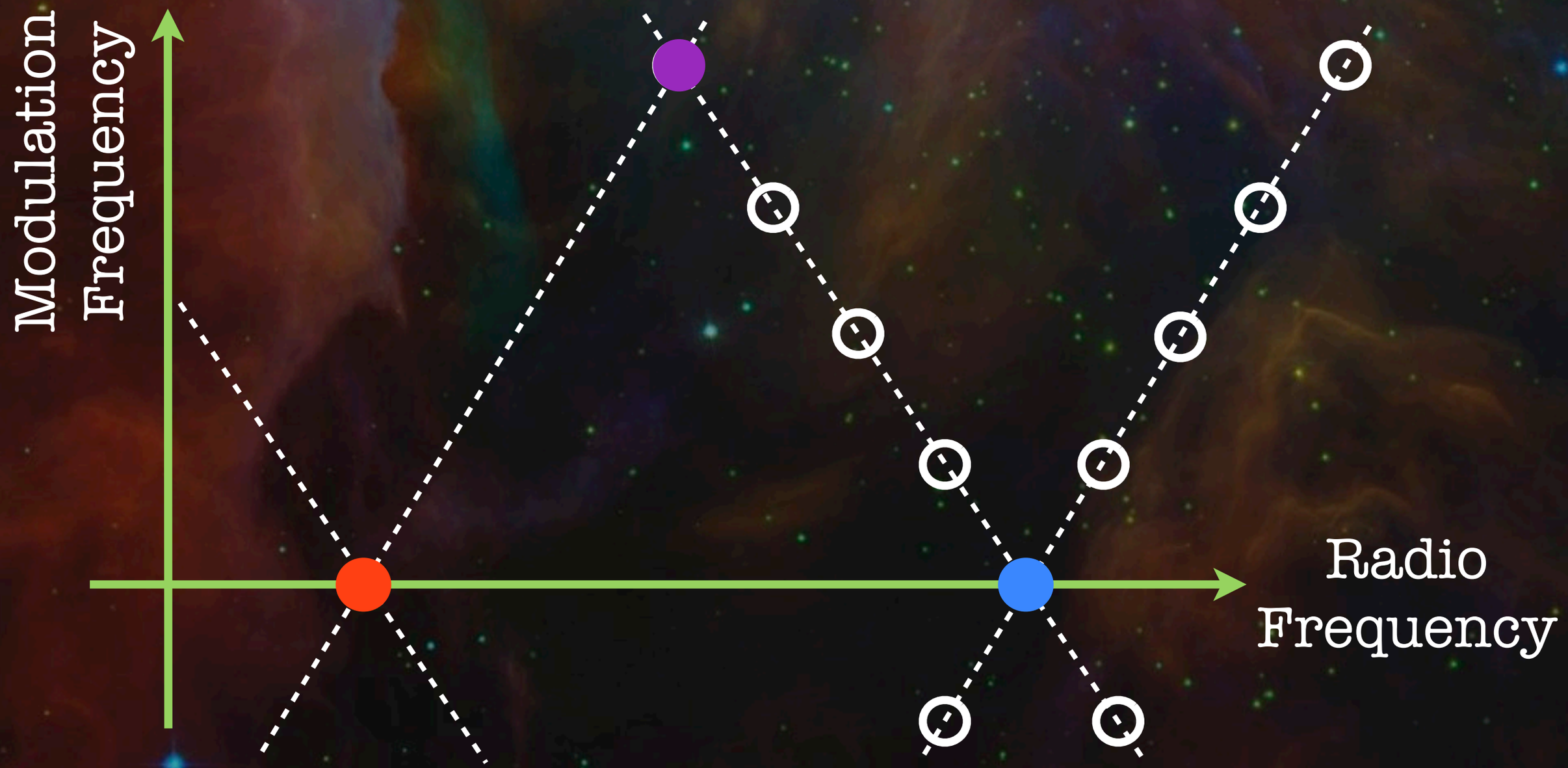
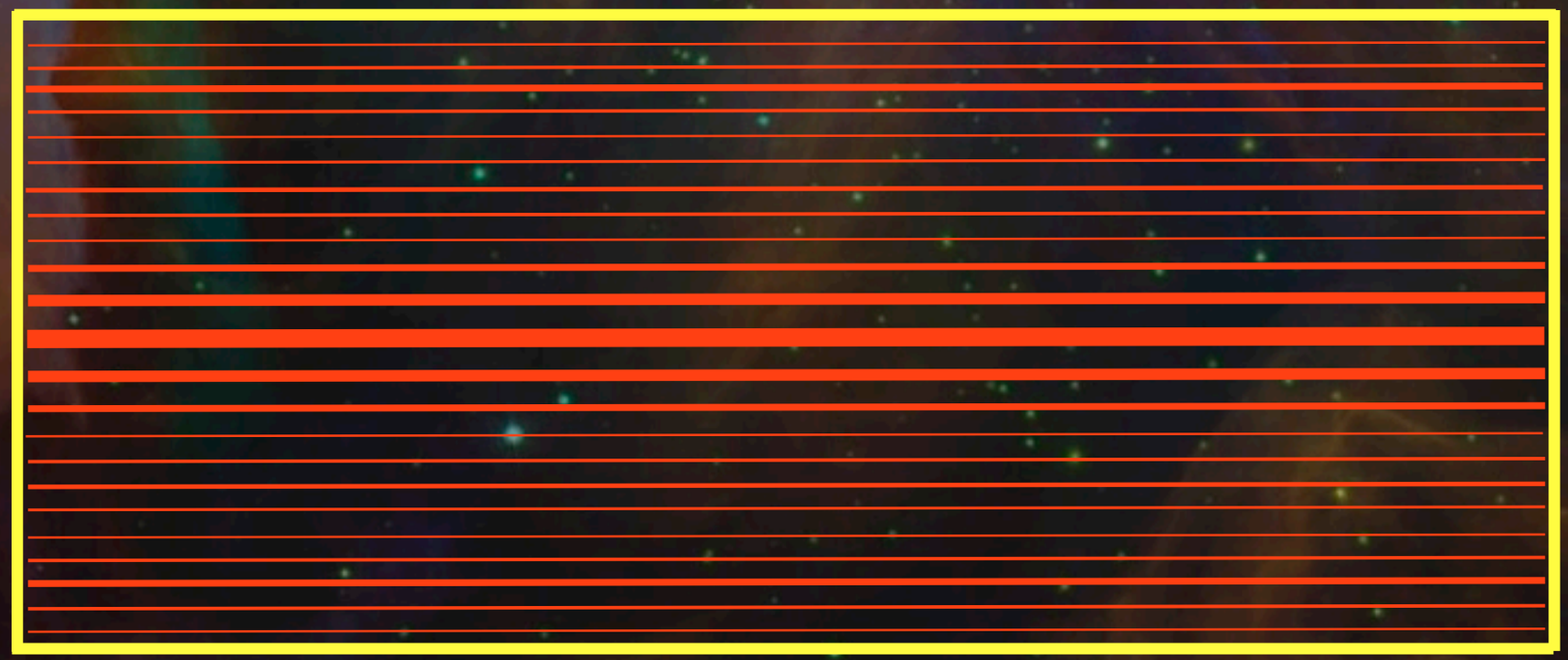


$$S(\alpha,\nu) = \langle E(\nu+\alpha/2)\, E^*(\nu-\alpha/2)\rangle$$

Intrinsic Cyclic Spectrum

Radio Frequency

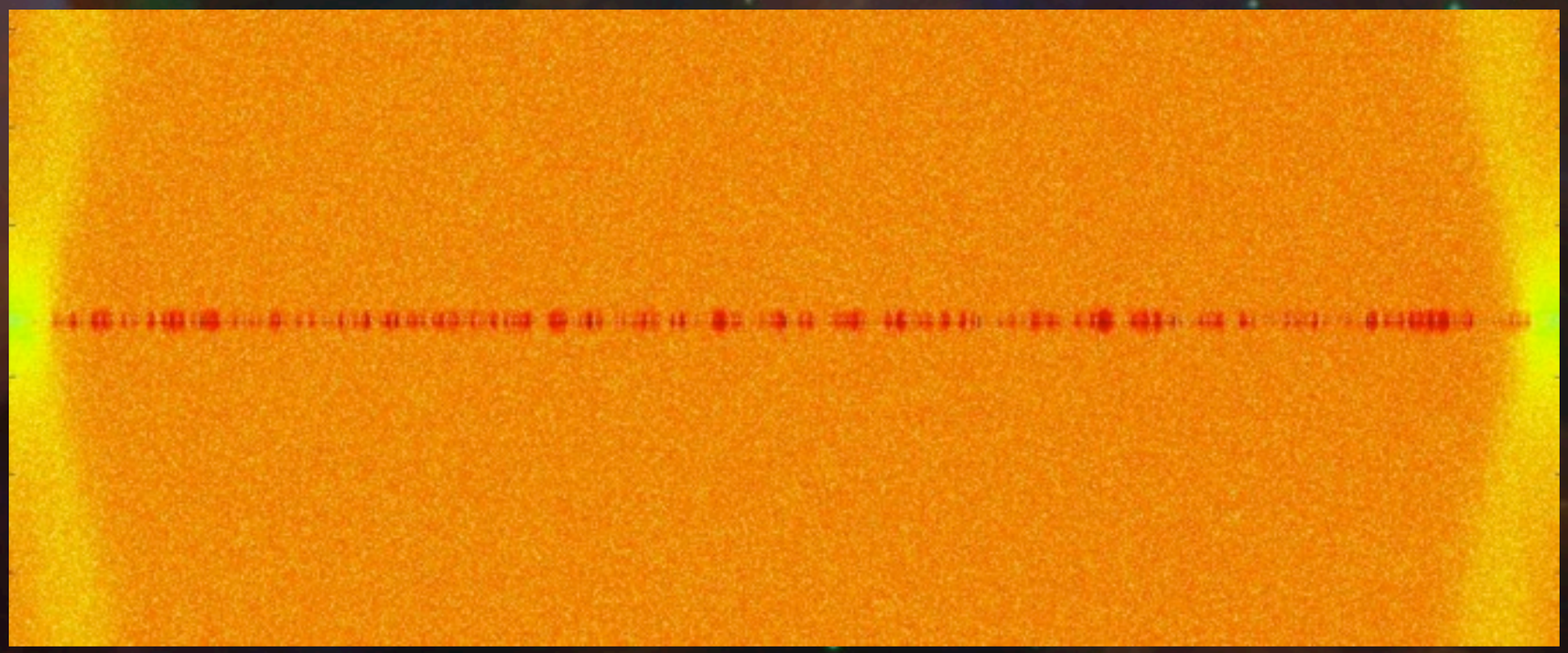


Modulation Frequency

$$S_o(\alpha,\nu) = \langle E_o(\nu+\alpha/2)\, E_o{}^*(\nu-\alpha/2)\rangle \rightarrow S_o(\alpha)$$

B1937+21 @ Arecibo, 428 MHz

Radio Frequency



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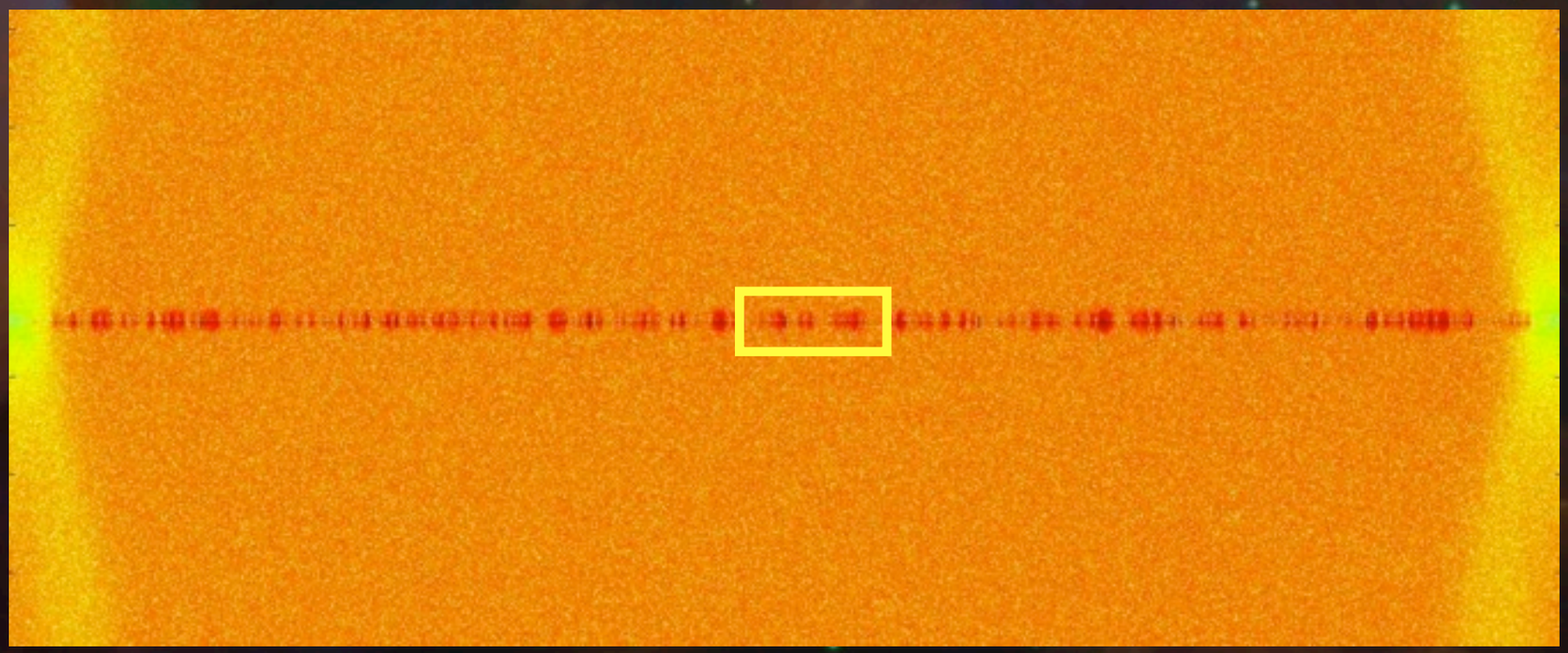

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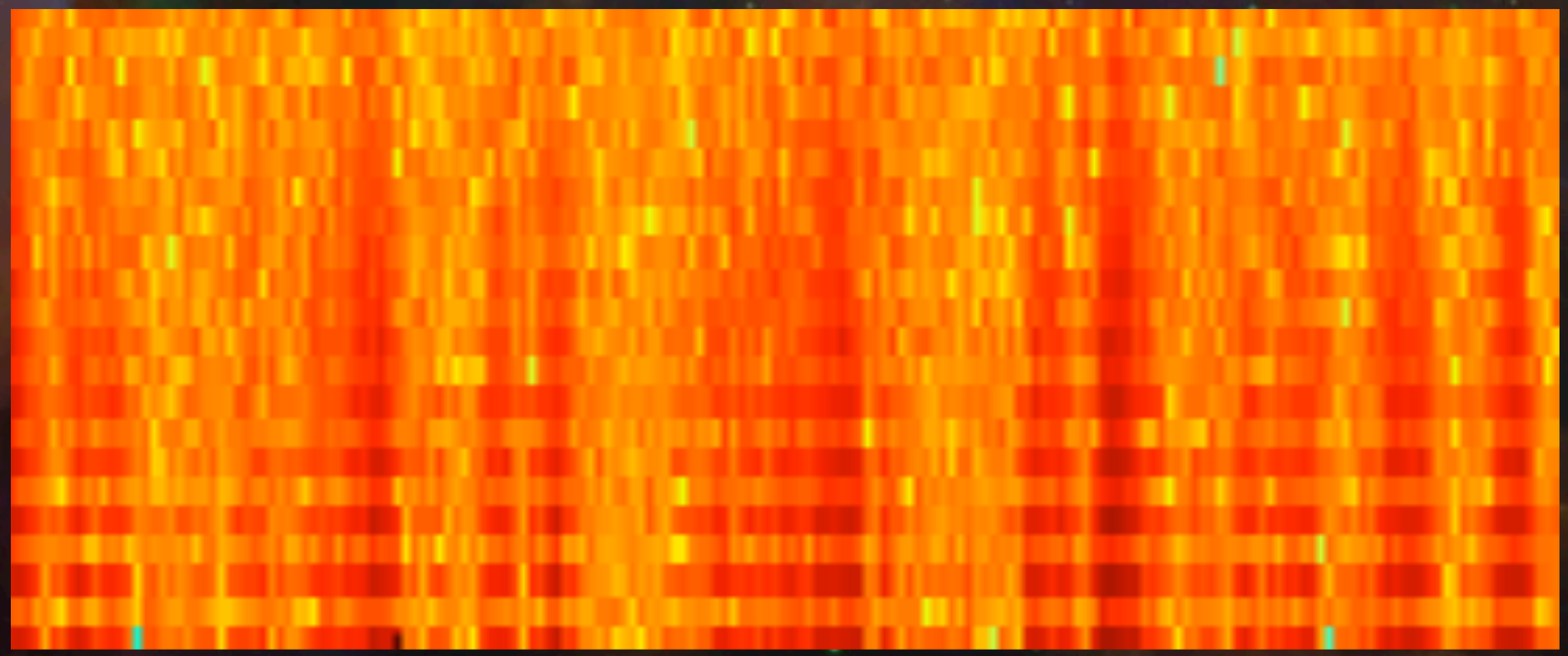

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$$E(\nu) = H(\nu)\, E_o(\nu)$$

$$S(\alpha,\nu) = H(\nu+\alpha/2)\, H^*(\nu-\alpha/2)\; S_o(\alpha)$$

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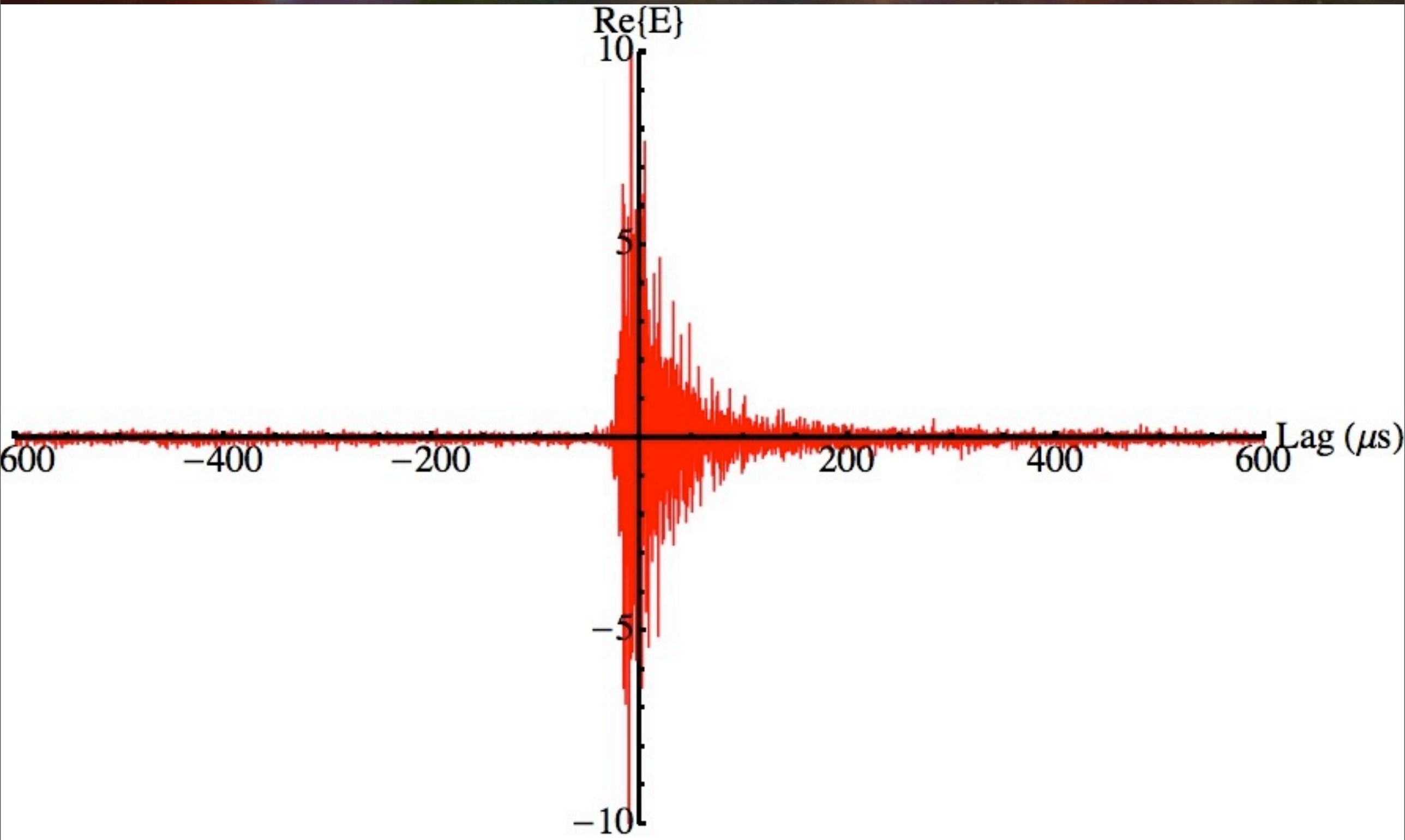
Extracting $H(\nu)$ and $S_o(\alpha)$

$$S(\alpha,\nu) = H(\nu+\alpha/2)\, H^*(\nu-\alpha/2)\, S_o(\alpha)$$

- Given $S_o(\alpha)$ we can fit for $H(\nu)$
  - Least-squares fit for $h(\tau)$ using L-BFGS

Extracting H(ν) and $S_o(\alpha)$



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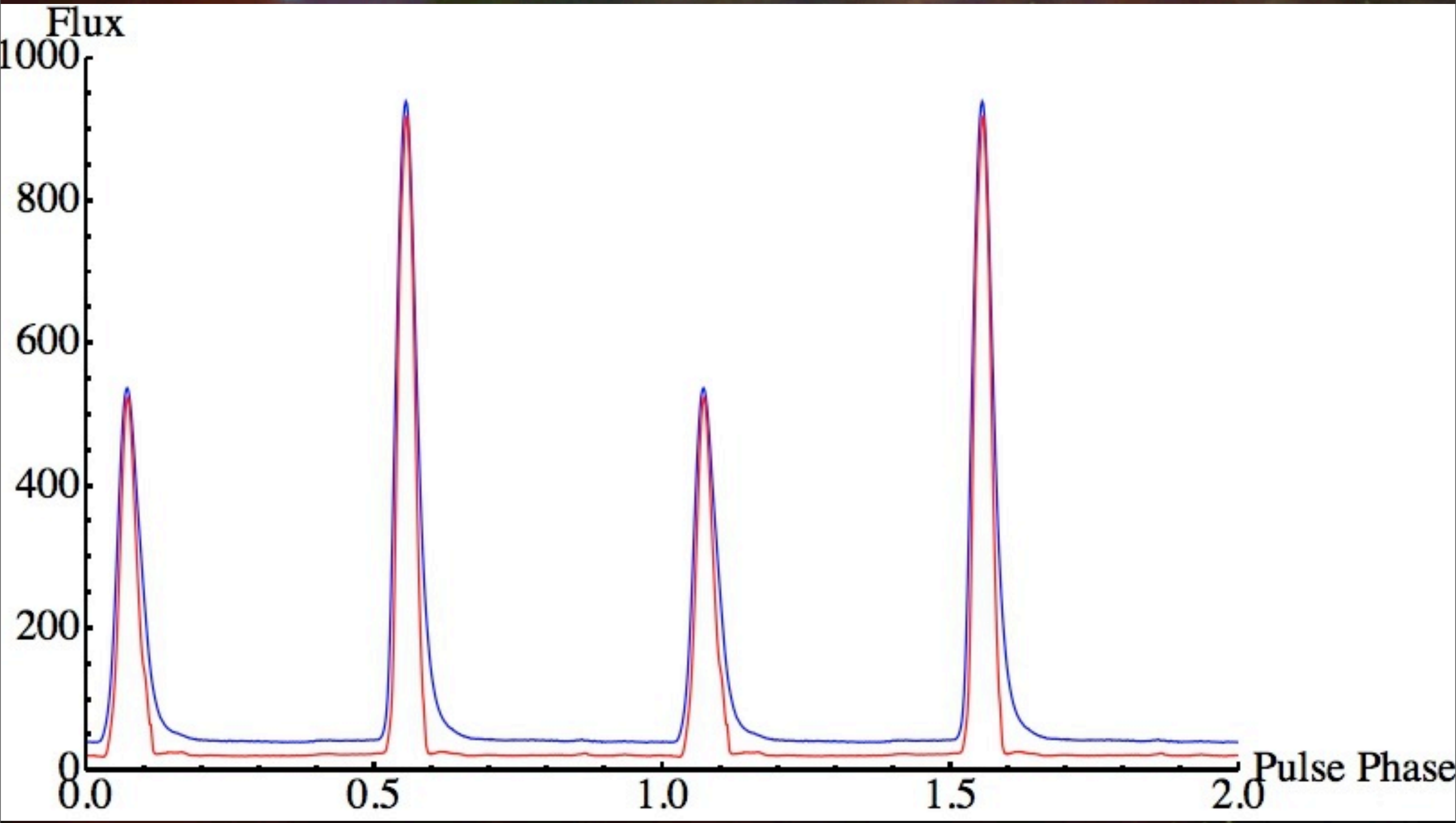
- Given $S_o(\alpha)$ we can fit for $H(\nu)$
  - Least-squares fit for $h(\tau)$ using L-BFGS
- Given $H(\nu)$ we can fit for $S_o(\alpha)$
  - One-step least-squares fit
- Average $S_o(\alpha)$ over whole observation
- Iterate

Extracting H(ν) and $S_o(\alpha)$



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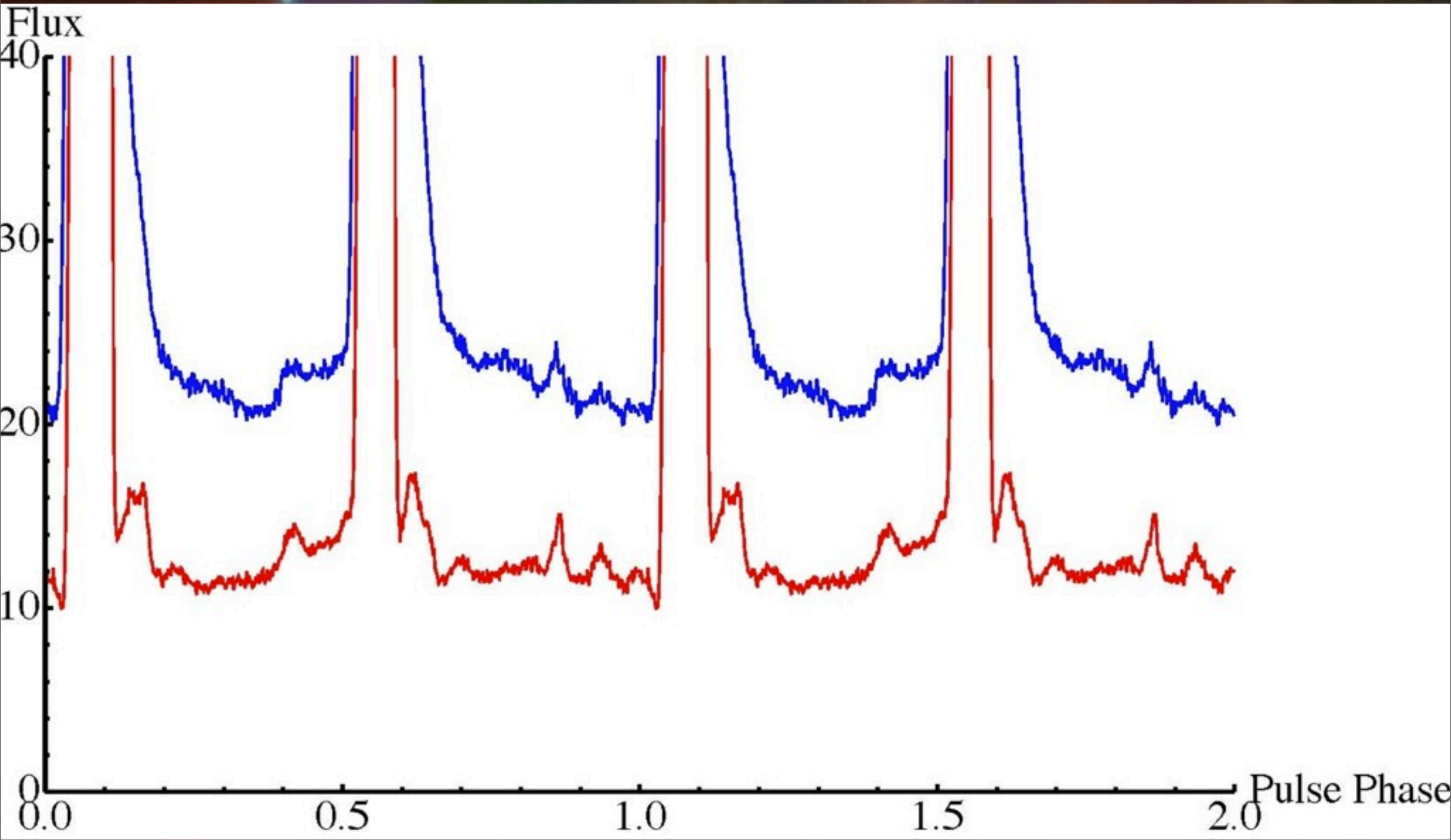

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- Average $S_o(\alpha)$ over whole observation
- Iterate
- $H(\nu)$ for every 10 sec sample $\rightarrow$ $H(\nu, t)$
  - Hence $h(\tau, \omega)$

Holographic Imaging

- Have detailed holographic information directly from cyclic spectrum : $h(\tau,\omega)$
- Need to model this as $n_e(x,y,z)$ on line-of-sight
  - Physics of ISM on AU-scales; Accurate TOAs
  - Accurate pulse timing

- GBT observations of J1518+4904

Anticipated Developments

- Currently only Stokes-I : want full Stokes
- Currently produce CS by post-processing voltages
  - Want real-time products :
    - V(t) → Stokes(α,ν) → h(τ) and $S_o(\alpha)$
- New Arecibo & GBT FPGA-based backends
  - Glenn Jones (Caltech) & PD
  - ~ 200 MHz (feeding PUPPI/GUPPI cluster)
- PKS : HIPSR ~ 400 MHz ?