Joint magnetospheres of solar-twin binary systems

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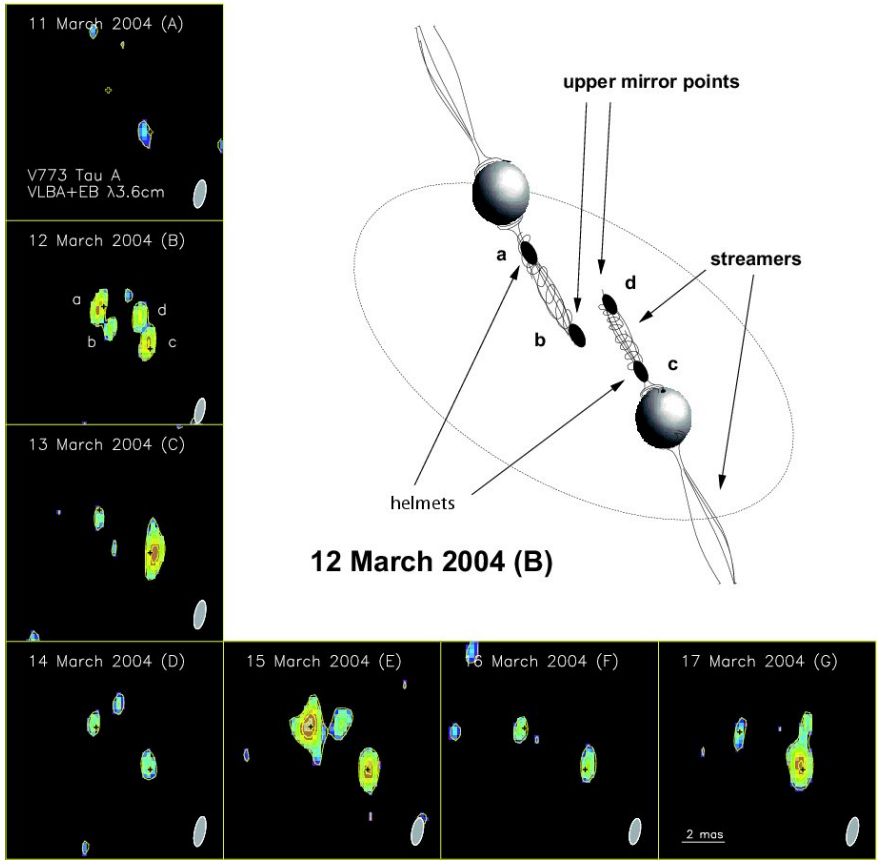
Magnetically interacting binaries

V773 Tau (Massi et al. 2006, 2008)

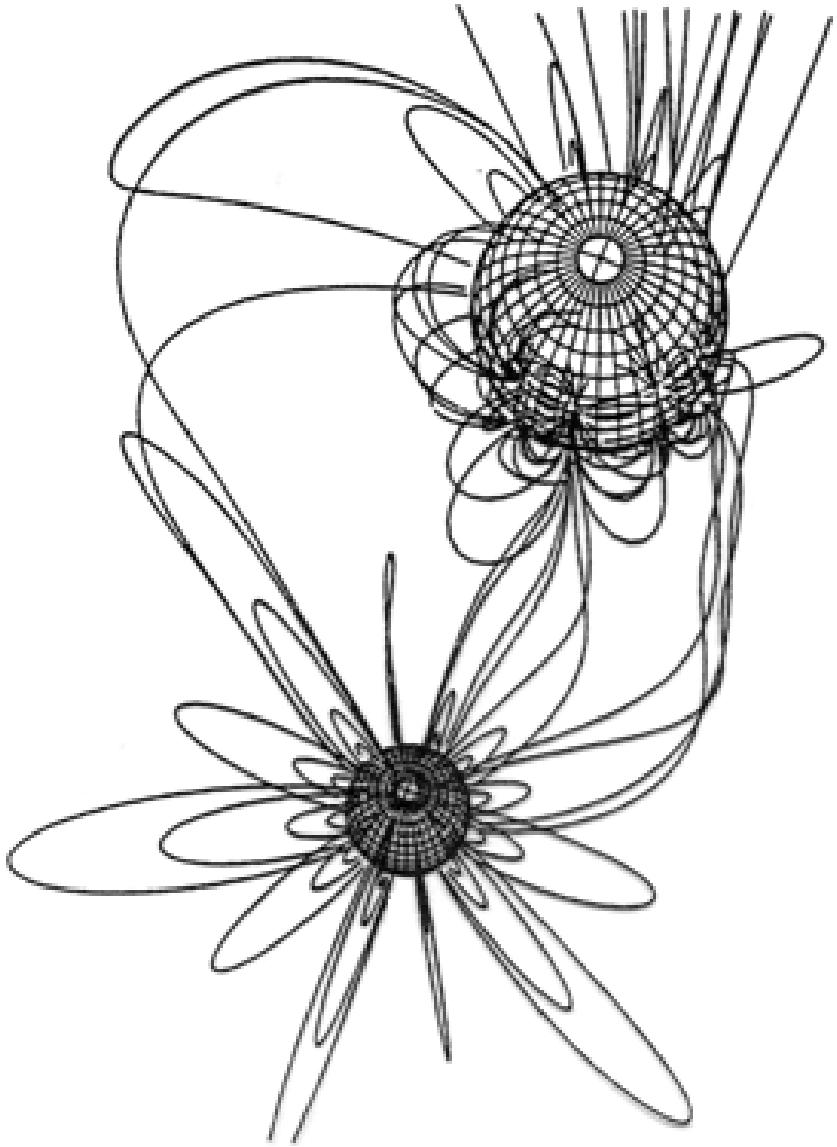
- periodic increase of radio emission around periastron
- flaring
- inter-binary collision of magentic field structures proposed



Magnetically interacting binaries

RS CVn-type systems (Uchida & Sakurai 1985)

- *Active Longitude Belt* concept
- loop system connecting both components
- two-temperature coronae



Joint magnetospheres of close binary systems

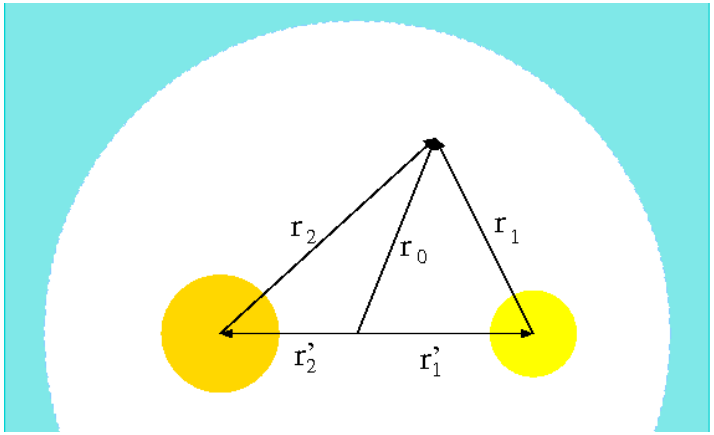
Overview

- *Objectives*: Investigation of
  - structure of joint magnetosphere
  - location of inter-connecting field structures
  - possible locations of magnetic activity signatures
  - thermal structure, X-ray emission, variability
  - mass transfer & condensations
  - ...
- *Method*: Magnetic field extrapolations using
  - binary potential field source surface (bPFSS) approximation
  - observed/simulated surface magnetic field distributions
- *Analyses*:
  - magnetic field structures & footpoints
  - coronal null points
  - magnetic loop lengths
  - ...

Model description

bPFSS extrapolation technique

- *Assumptions*:
  - **current-free** magnetic field: $\mathbf{B} = -\nabla\Psi$
  - potential Ψ solution of $\Delta\Psi = 0$
  - **source surface** concept:
    - sphere enclosing binary components
    - **B** radial on source surface
    - mimicing impact of stellar winds

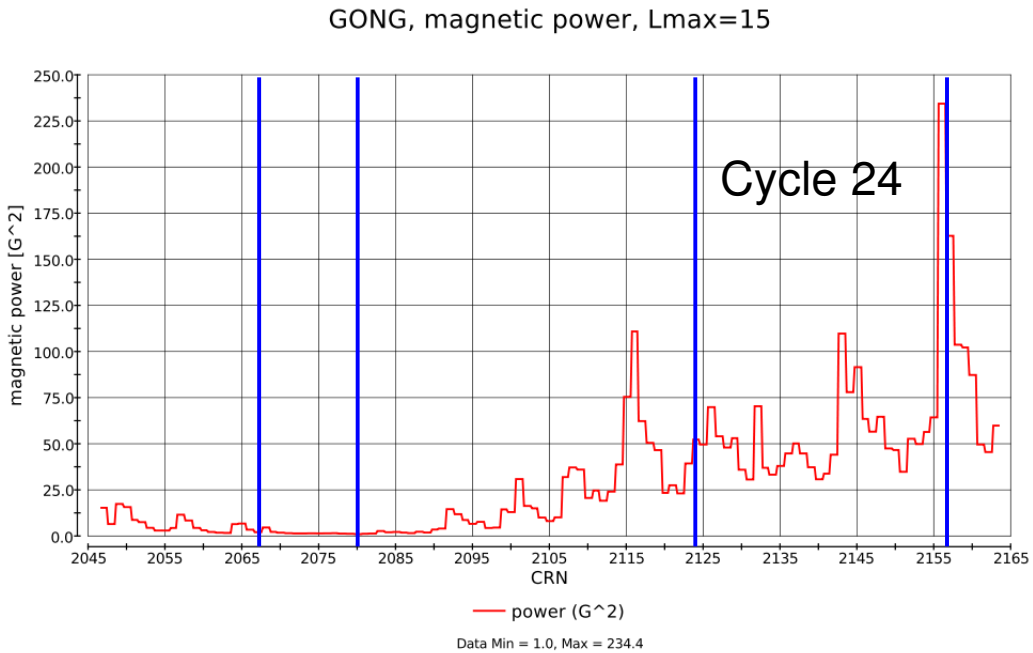


- *Method*:
  - potential field expansion in terms of solid spherical harmonics (SSH)
  - SSH translation using **multipole translation theorems**
  - solution coefficients from linear system of equations

    NB expandable to N objects (e.g. circumbinary exoplanets)
  - solution determined by **boundary conditions**

’Solar-twin’ binary system

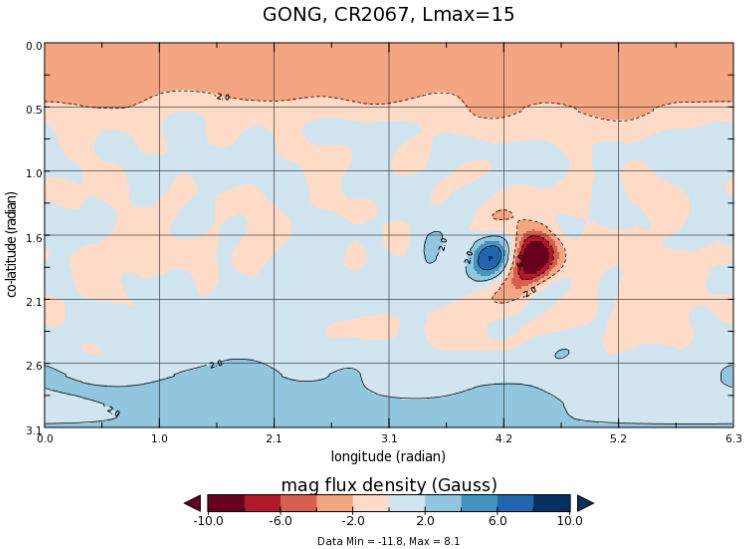
- *Objective*: **different activity states** of solar-type binary components
- *System parameters*:
  - binary separation: $6R_\odot$
  - stellar component radii: $1R_\odot$
  - source surface radius: $10R_\odot$
- *Boundary conditions*:
  - source surface: $\mathbf{B}_\perp = 0$
  - stellar surfaces:
    - GONG synoptic $\mathbf{B}_\mathrm{r}$ maps
    - **inactive** states:
      CRN 2067, CRN 2080
    - **active** states:
      CRN 2124, CRN 2157

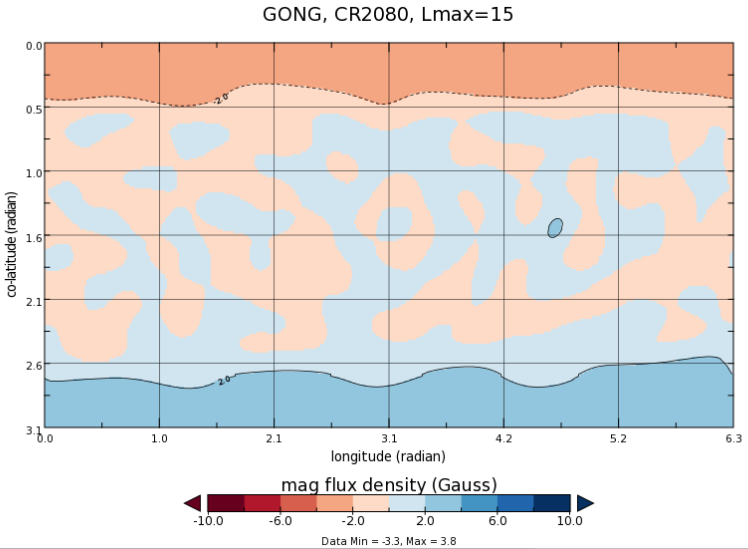


’Solar-twin’ binary system

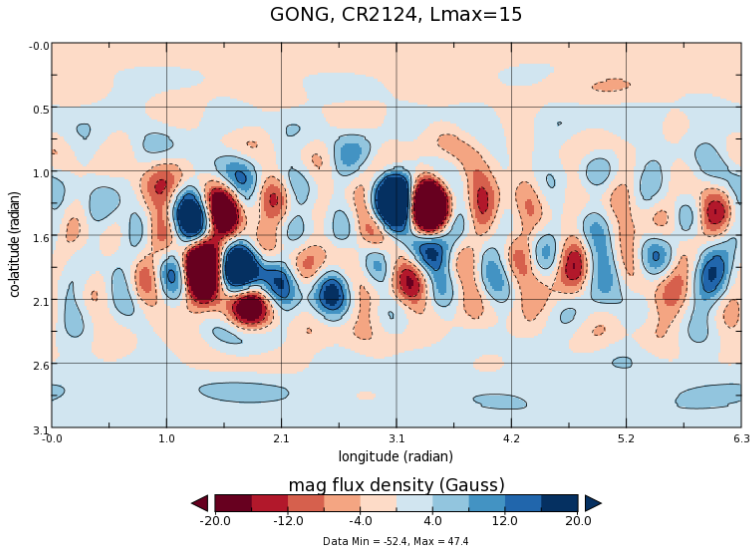
Spherical harmonic synthesis of GONG synoptic $\mathbf{B}_r$ maps

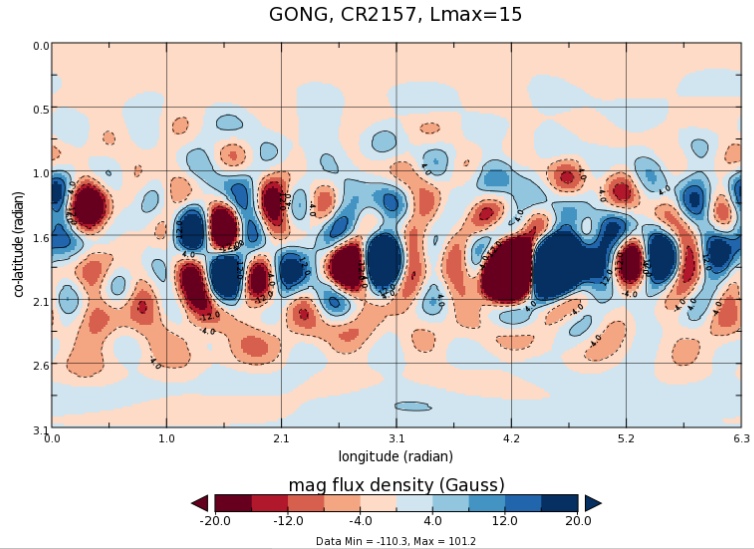
’inactive’ states





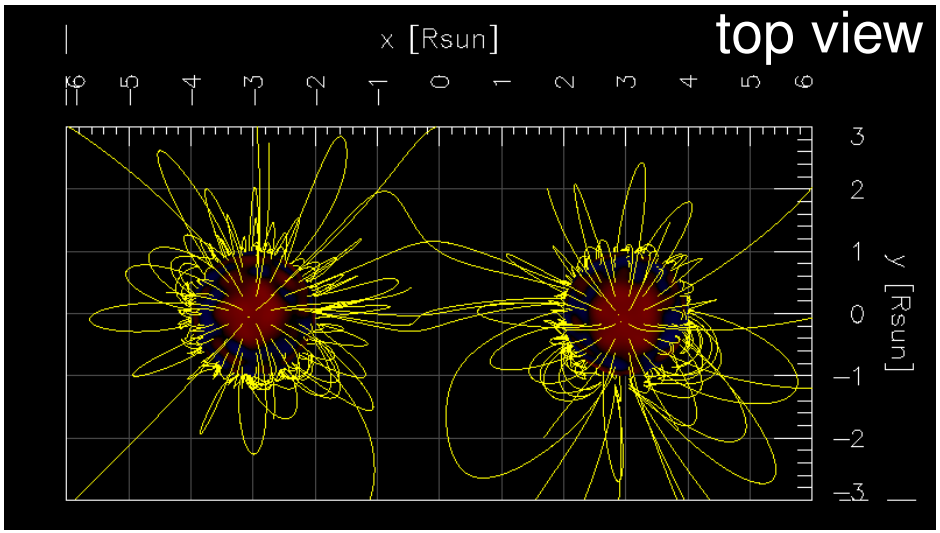
’active’ states

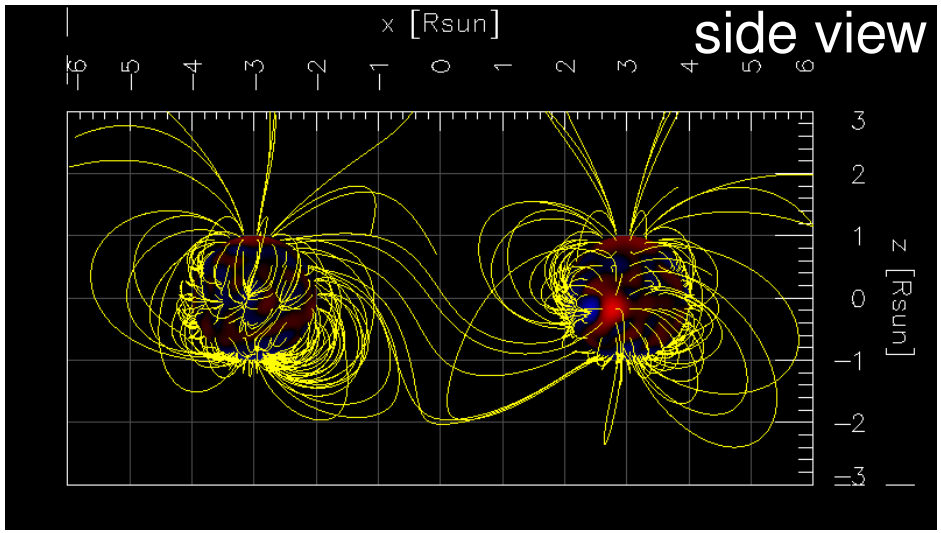


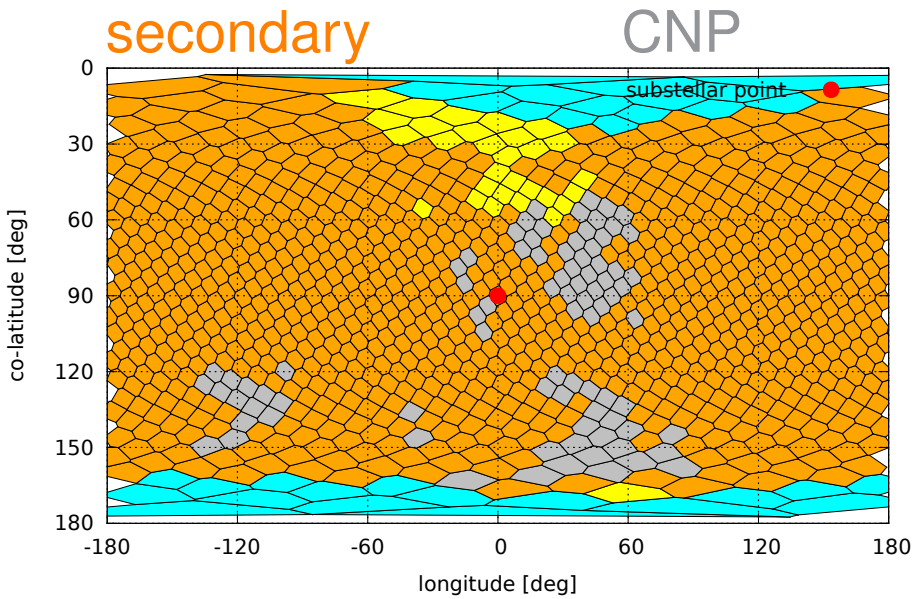


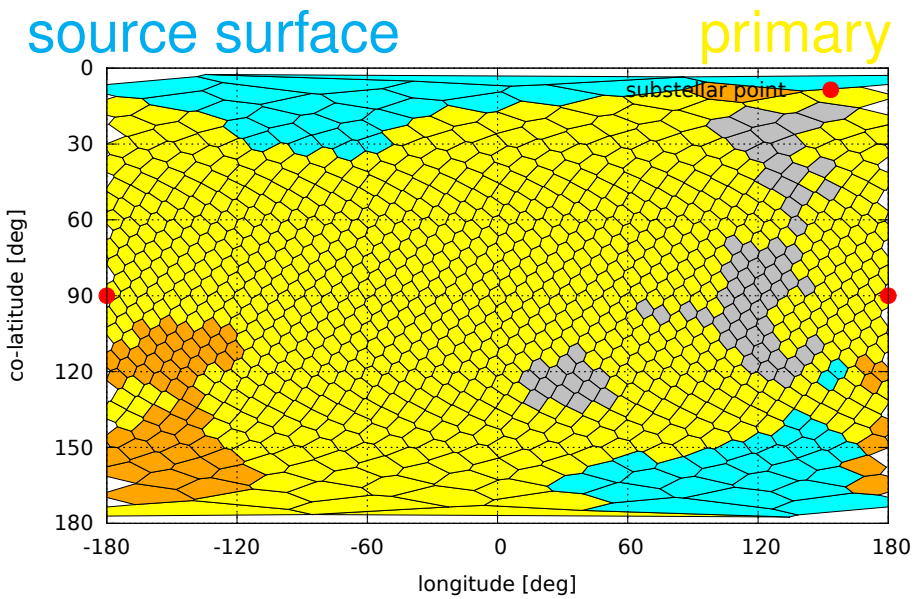
’Solar-twin’ binary system (inactive states)

secondary: CRN2080/**IA**, primary: CRN2067/**IA**



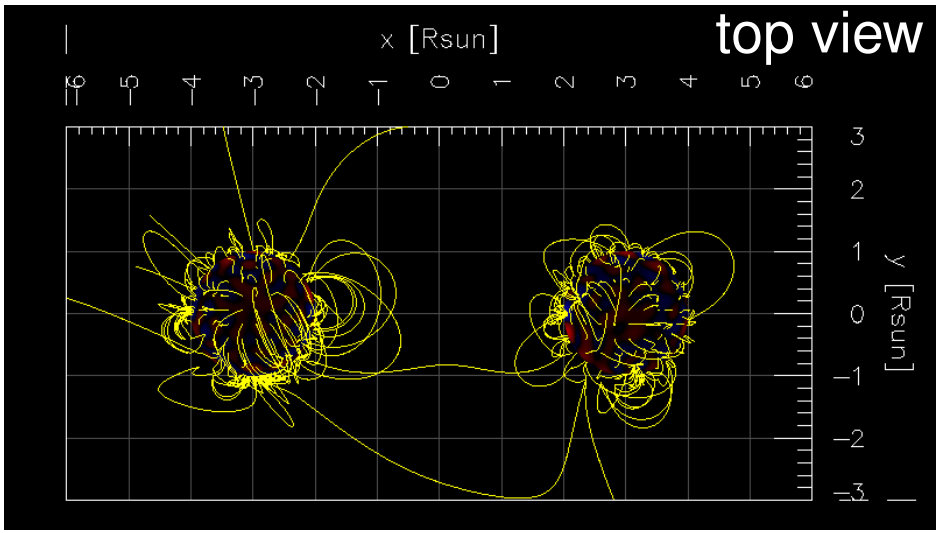


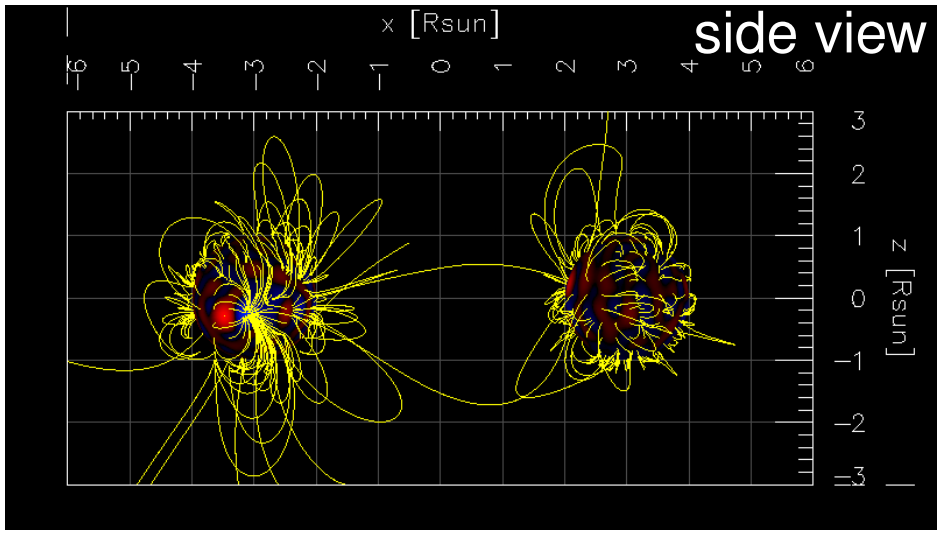


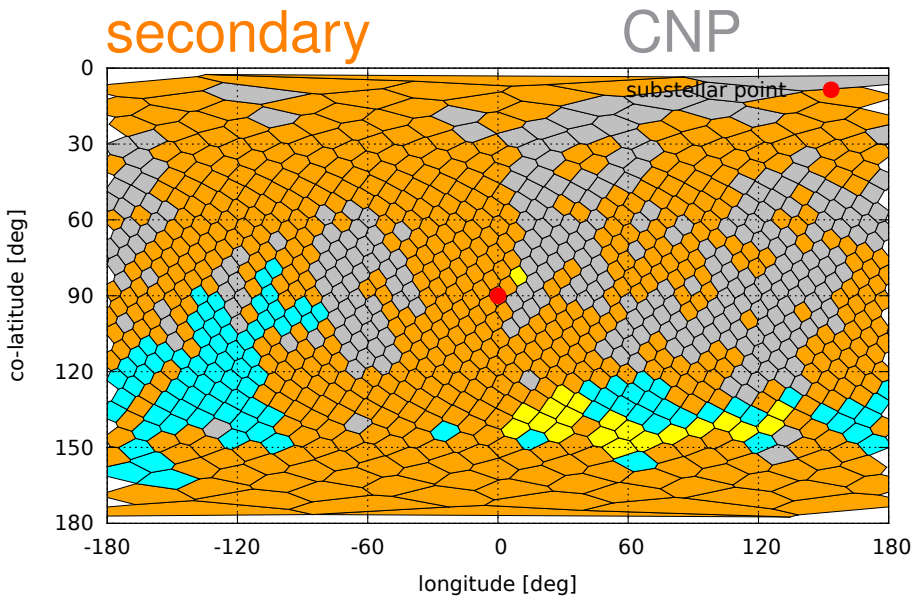


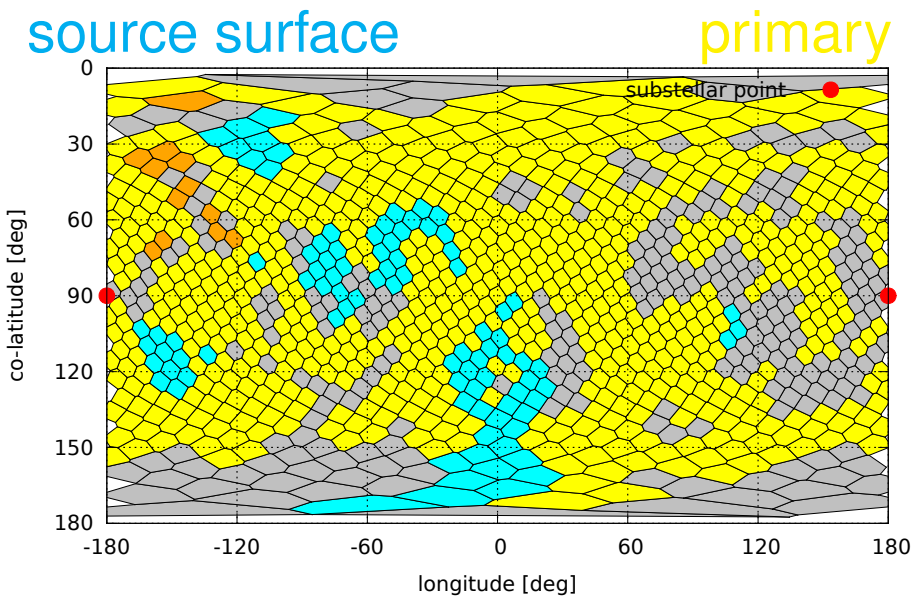
’Solar-twin’ binary system (active states)

secondary: CRN2157/**AC**, primary: CRN2124/**AC**



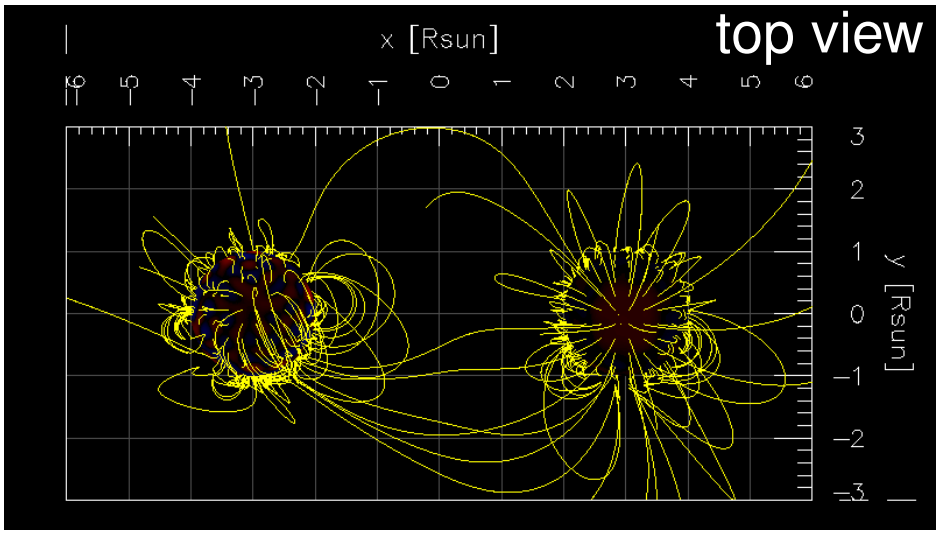


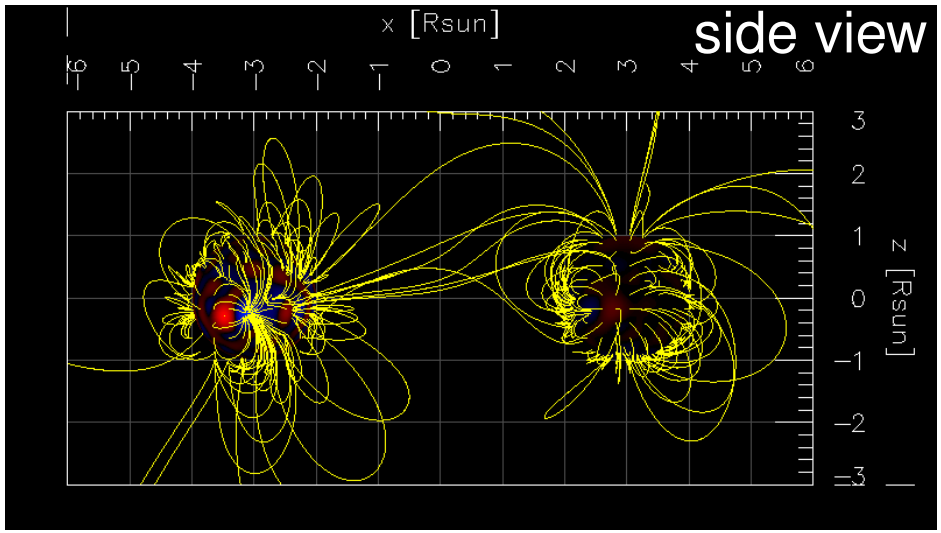


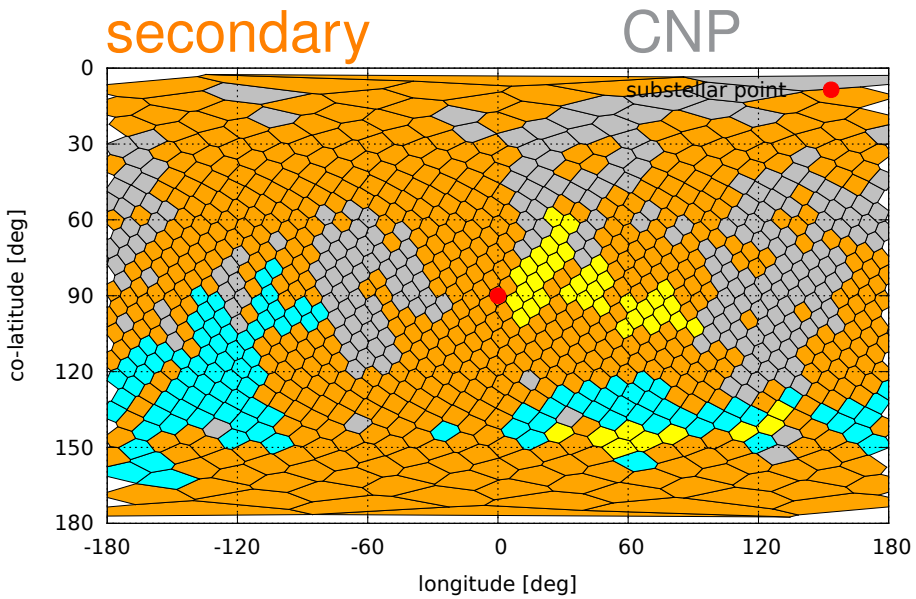


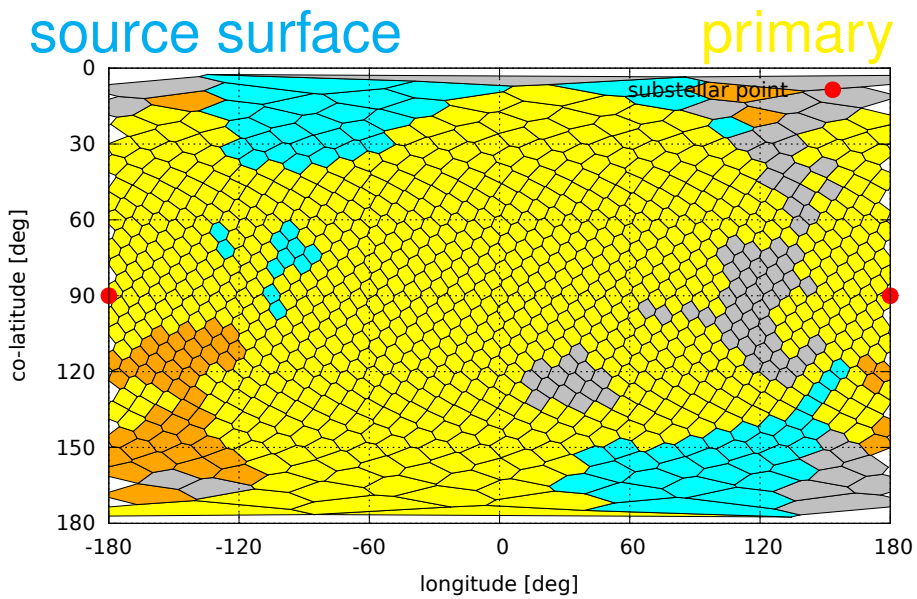
’Solar-twin’ binary system (mixed states)

secondary: CRN2157/**AC**, primary: CRN2067/**IA**







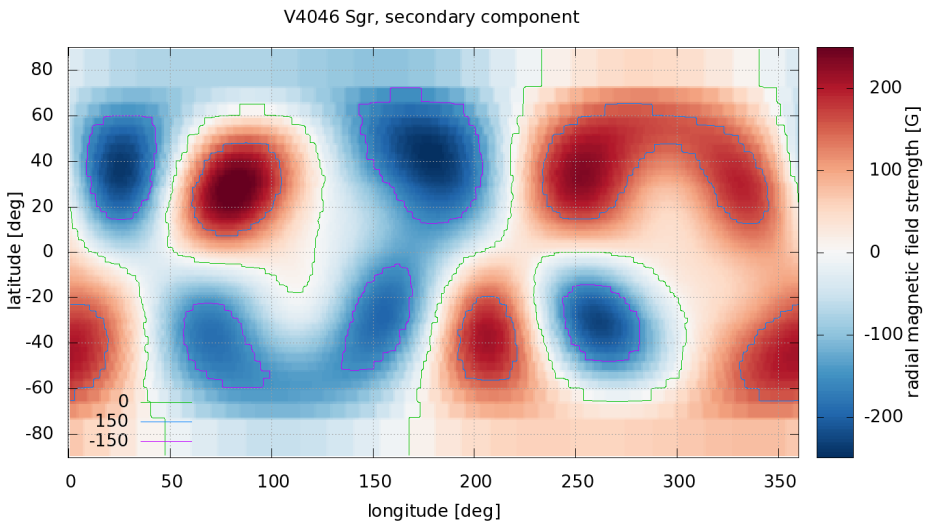


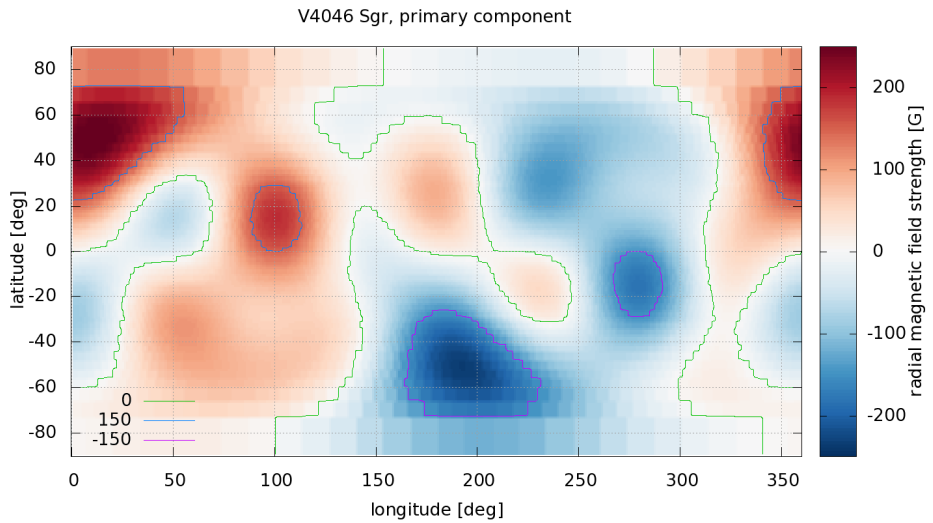
Observed system V4046 Sgr

- accreting PMS binary, distance $\sim 73pc$, age $\sim 13Myr$
- system parameter:

component	position $\bar{x}[R_\odot]$	radius $a[R_\odot]$
primary	4.3	1.12
secondary	-4.5	1.04

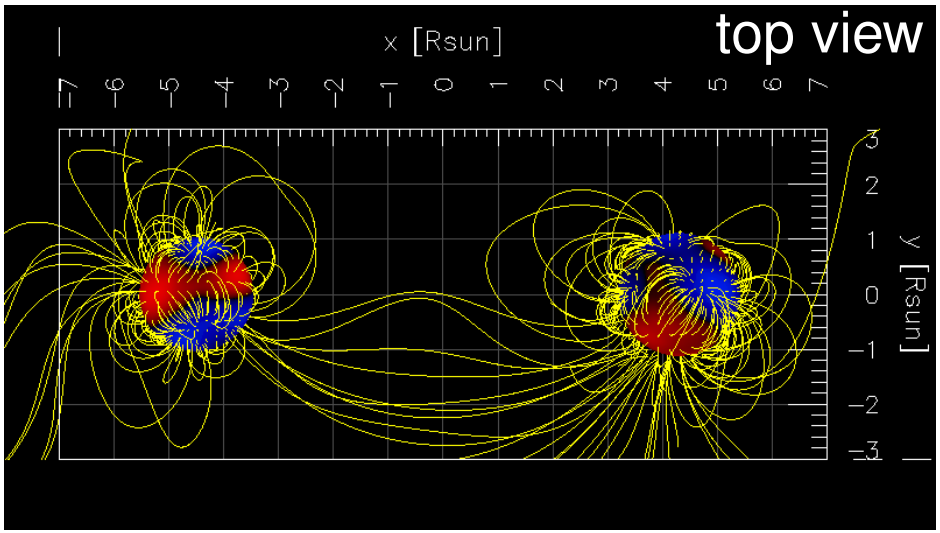
- magnetic surface maps: (Donati et al. 2011)

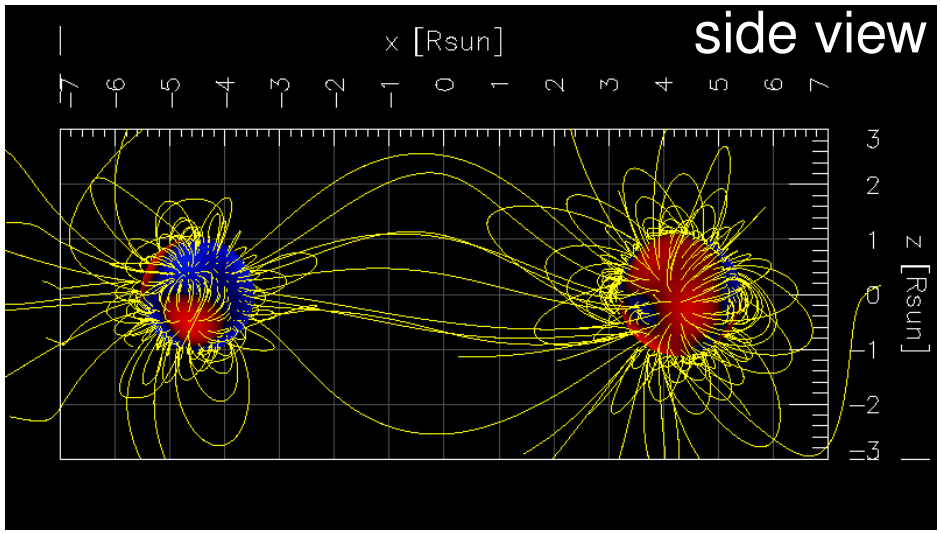


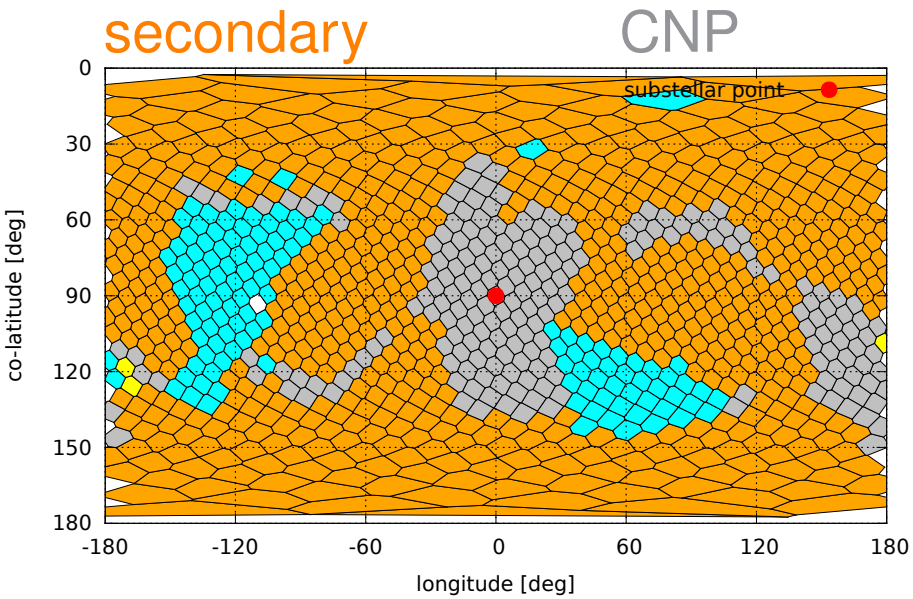


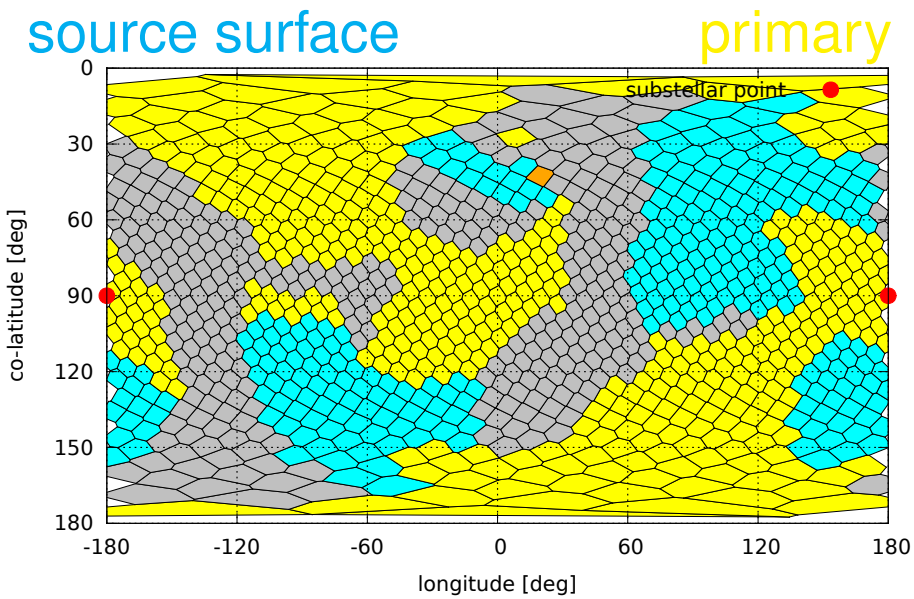
V4046 Sgr (Holzwarth & Gregory 2015)

surface maps based on ZDI reconstuctions (Donati et al. 2011)









Summary

- *Solar-twin binary system*:
  - based on bPFSS approximation
  - using GONG synoptic maps
- *Different activity states*:
  - inactive: low degree modes dominate → more inter-connection
  - active: high degree modes dominate → less inter-connection
- *Activity/CNP* near substellar point?
- *Outlook*:
  - more CNPs in active states; inter-connection?
  - distribution of CNPs
  - revision of field integration technique