# Influence of the Disk Wind on the Intrinsic Polarization of Young Stars

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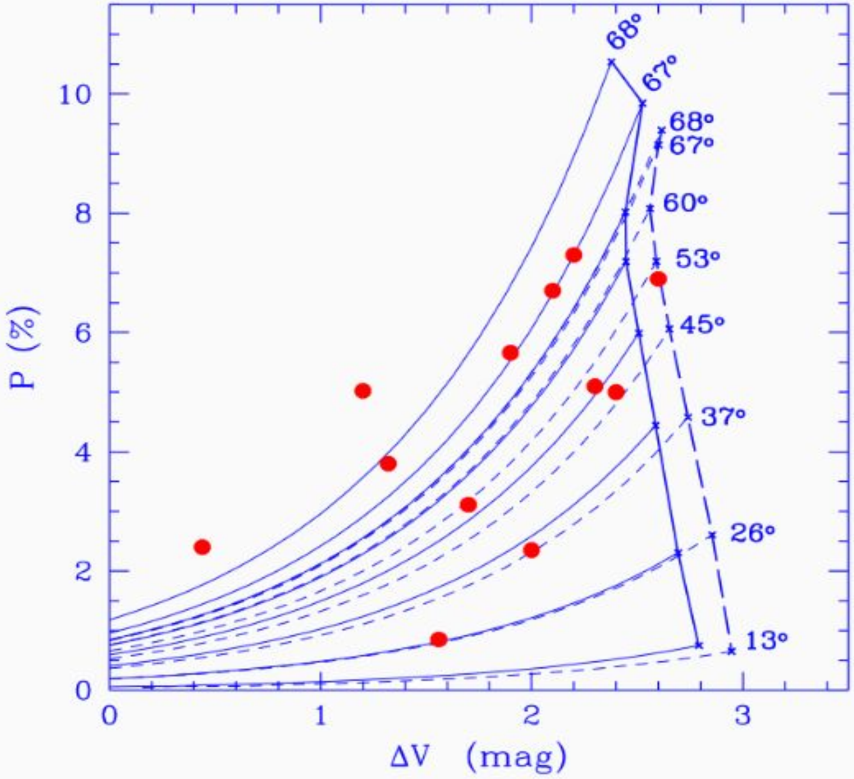
# UX Ori Type Stars

Intermediate mass, pre-main sequence Herbig Ae/Be stars with a specific type of variability:

- The light curves show Algol like fadings up to 2-3 magnitudes
- random intervals of days to weeks between fadings
- changes in color
- increase in linear polarization to 5-8%

# Conservative Model

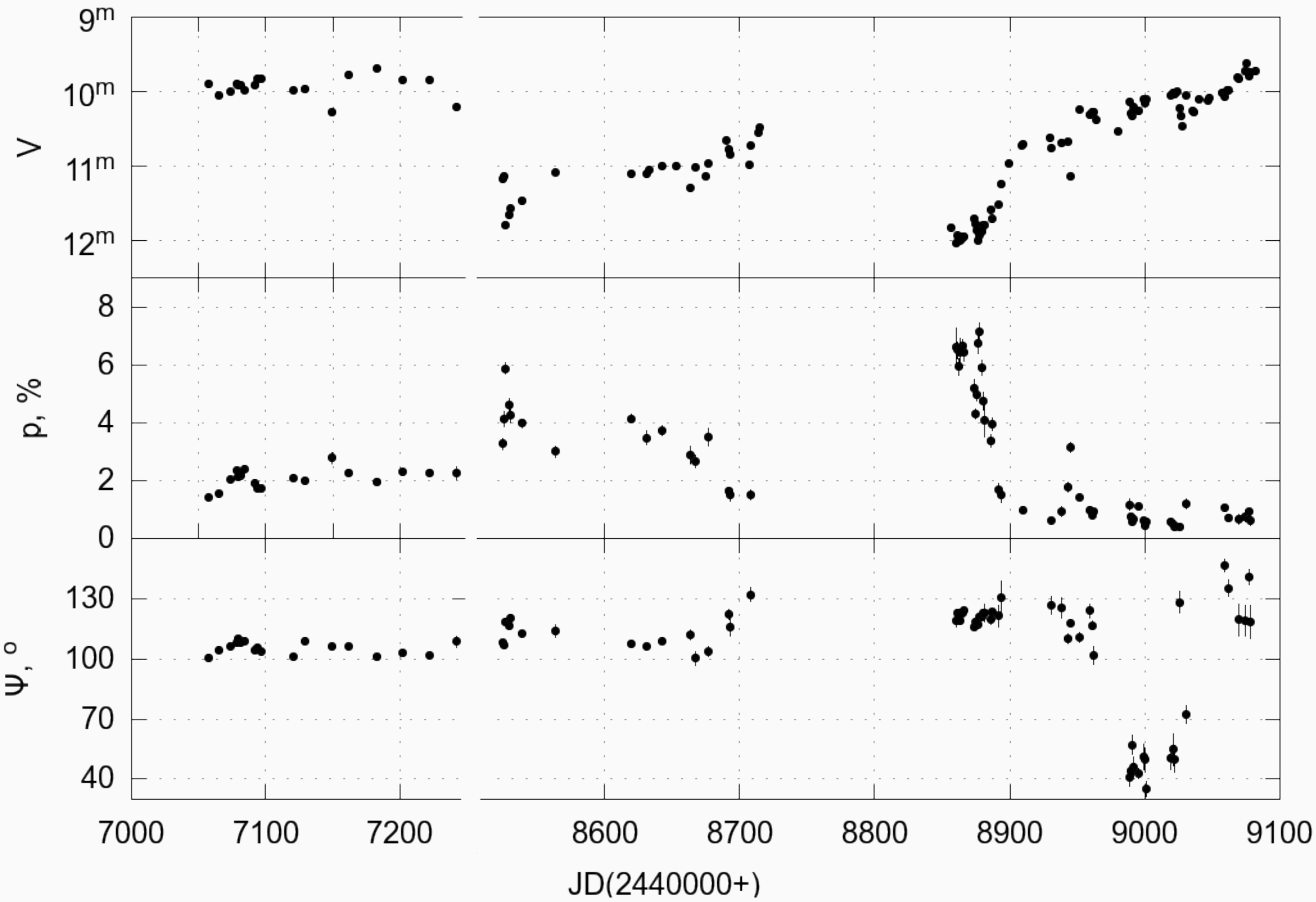



Grinin (1988):

- Compact gas-dust clumps (clouds)
- Linear polarization positional angle has no changes
- Explains the majority of events

Natta and Whitney (2000): eclipse models for a thin disk

# UX Ori Deep Minimum




Grinin et. al. (1994)

# Tasks

- Expand conservative model for a star with a circumstellar disk puffed up in the inner region.
- Study eclipses caused by large scale circumstellar disk perturbation

# Directions Grid Enumeration Method

Effective three-dimensional dust radiative transfer based on enumeration using the directions grid and the law of total probability.

Finite number of discrete levels of photon packets properties.

- No random noise. No need in realization statistics. Photon packets always have correct distributions.
- Neighboring realizations can be kept effective.

(Shulman, 2018)

# Disk and Wind Models

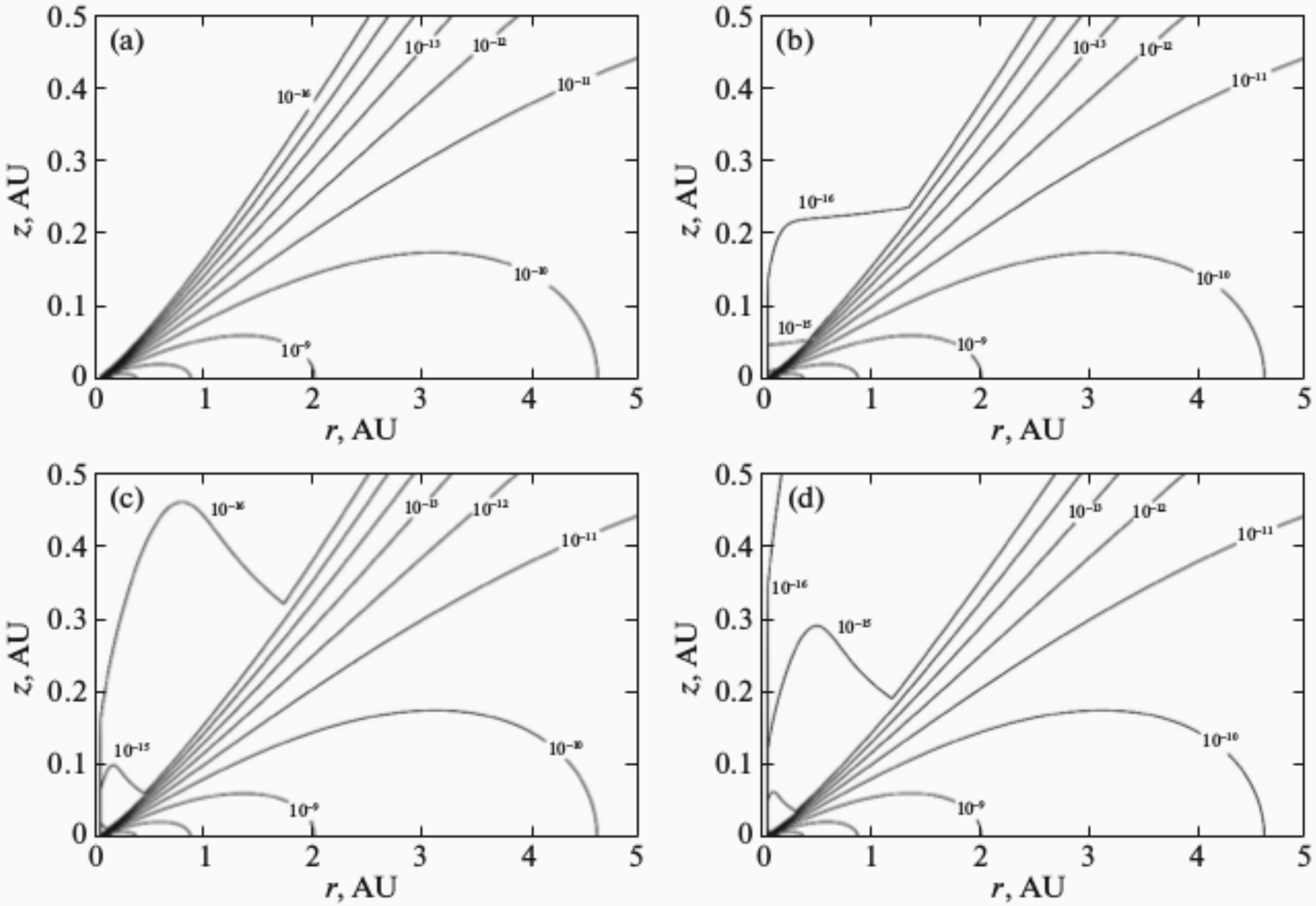
$$\rho(x,y,z) = \begin{cases} \rho_0 \left(\frac{R_0}{r}\right)^{\alpha} \exp\left[-\frac{1}{2}\left(\frac{z}{h(r)}\right)^2\right], & R_i \leq r \leq R_d, \\ 0, & \text{otherwise,} \end{cases}$$

$$r = \sqrt{x^2 + y^2}, \qquad h(r) = h_0 \left(\frac{r}{R_0}\right)^{\beta}$$

The disk puffing in the dust sublimation zone is produced by a disk wind. Safier (1993):

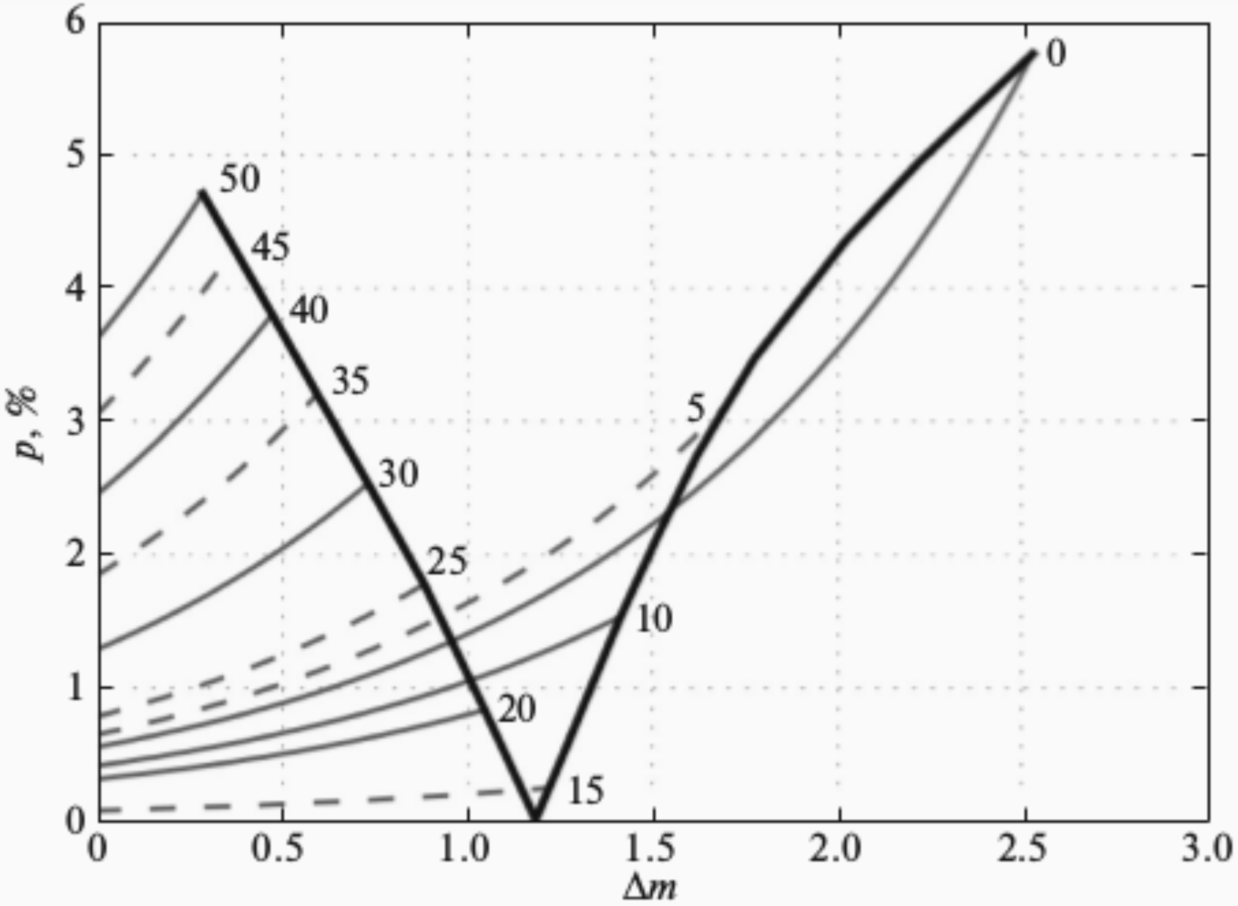
$$\rho = \rho_0 \left(\frac{r}{r_0}\right)^{-3/2} \eta(\chi)$$

# Disk Puffing Up

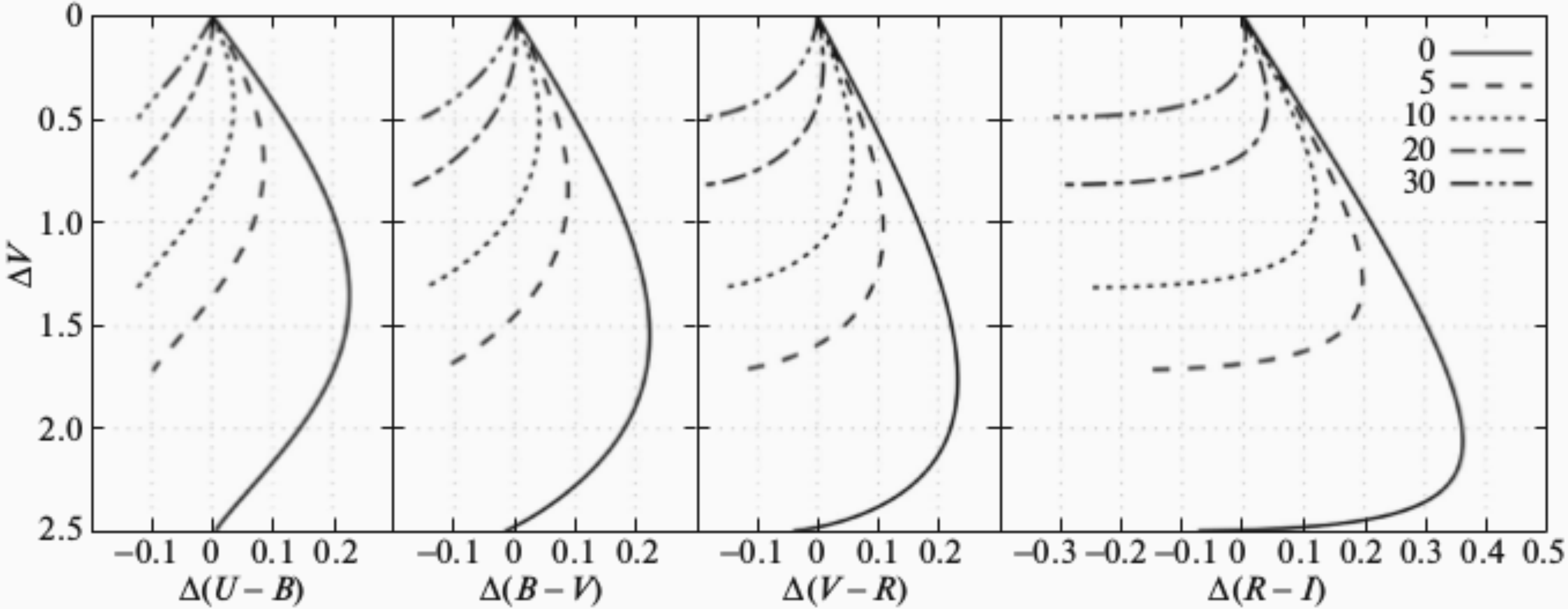



(a) no wind
(b) F $10^{-8}$ $M_{\odot}$ / year
(c) C $10^{-8}$ $M_{\odot}$ /year
(d) C 5 $10^{-8}$ $M_{\odot}$/ year

# Polarization - Magnitude



# Color



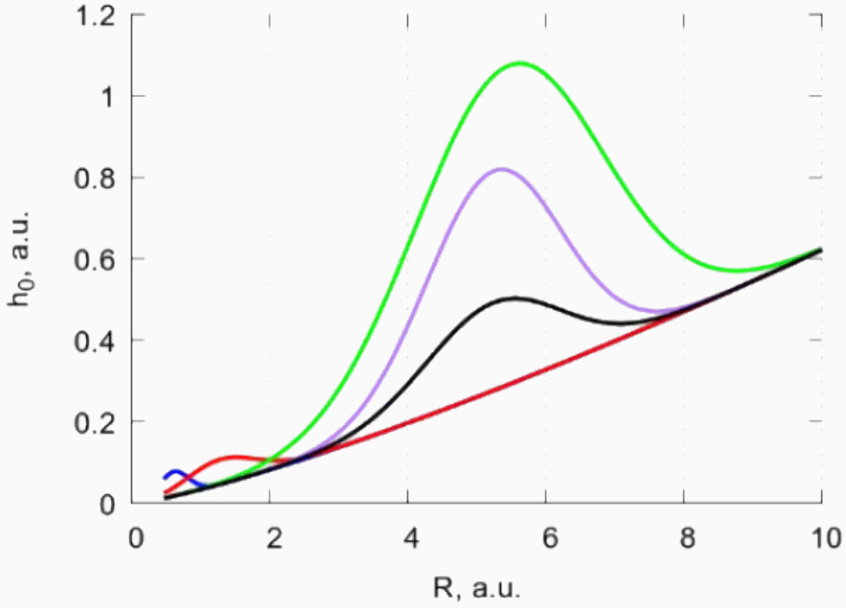

Shulman & Grinin (2019)

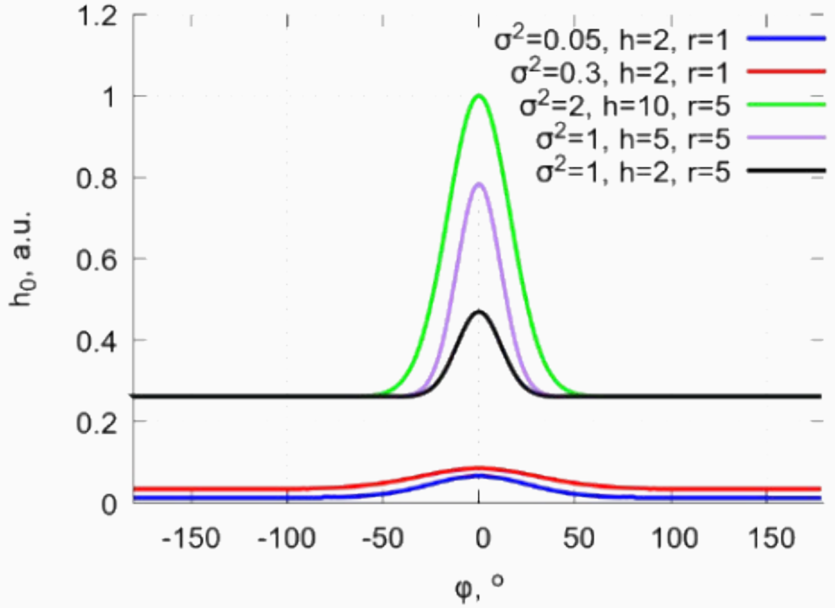
# Results

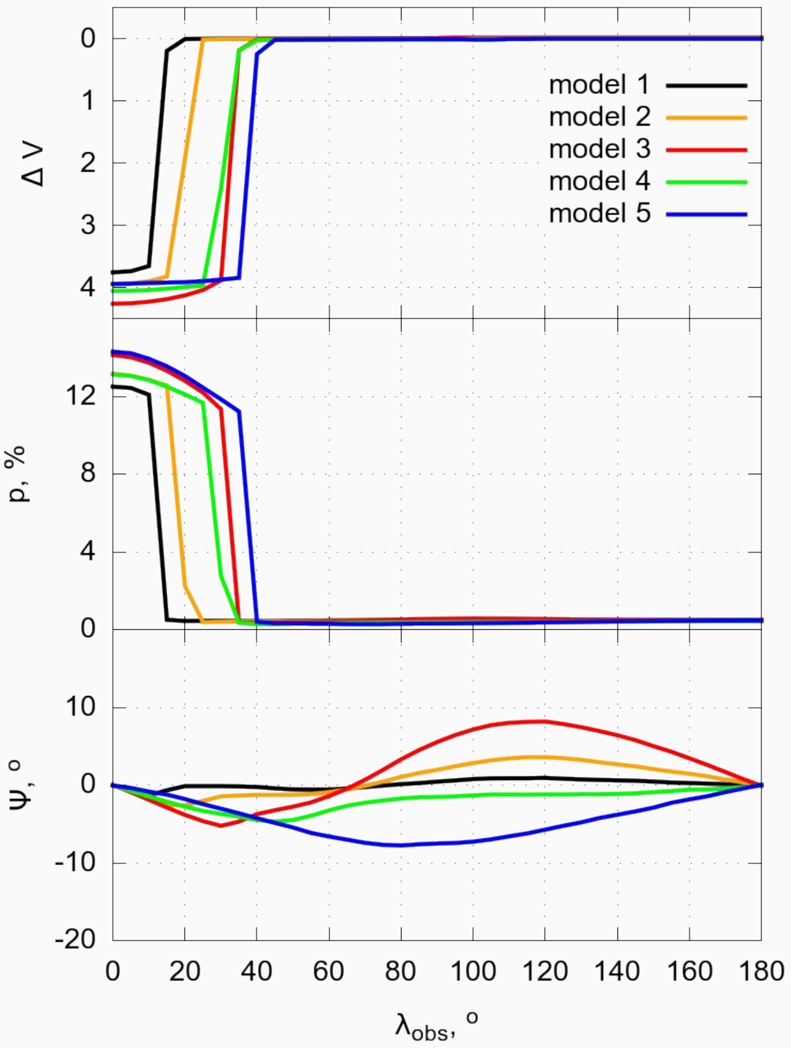
- The position angle of polarization may differ by 90° on different wavelengths (Pereyra et al.  2009)
- The polarization may not change during the eclipse (Rostopchina-Shakhovskaya et al. 2012)
- There can be no reddening of the star: color indices may decrease during the all fading (Grady et al. 1995)
- Large scatter of polarization parameters at the same brightness level is possible (Rostopchina et al. 2000)

# Disk Perturbation

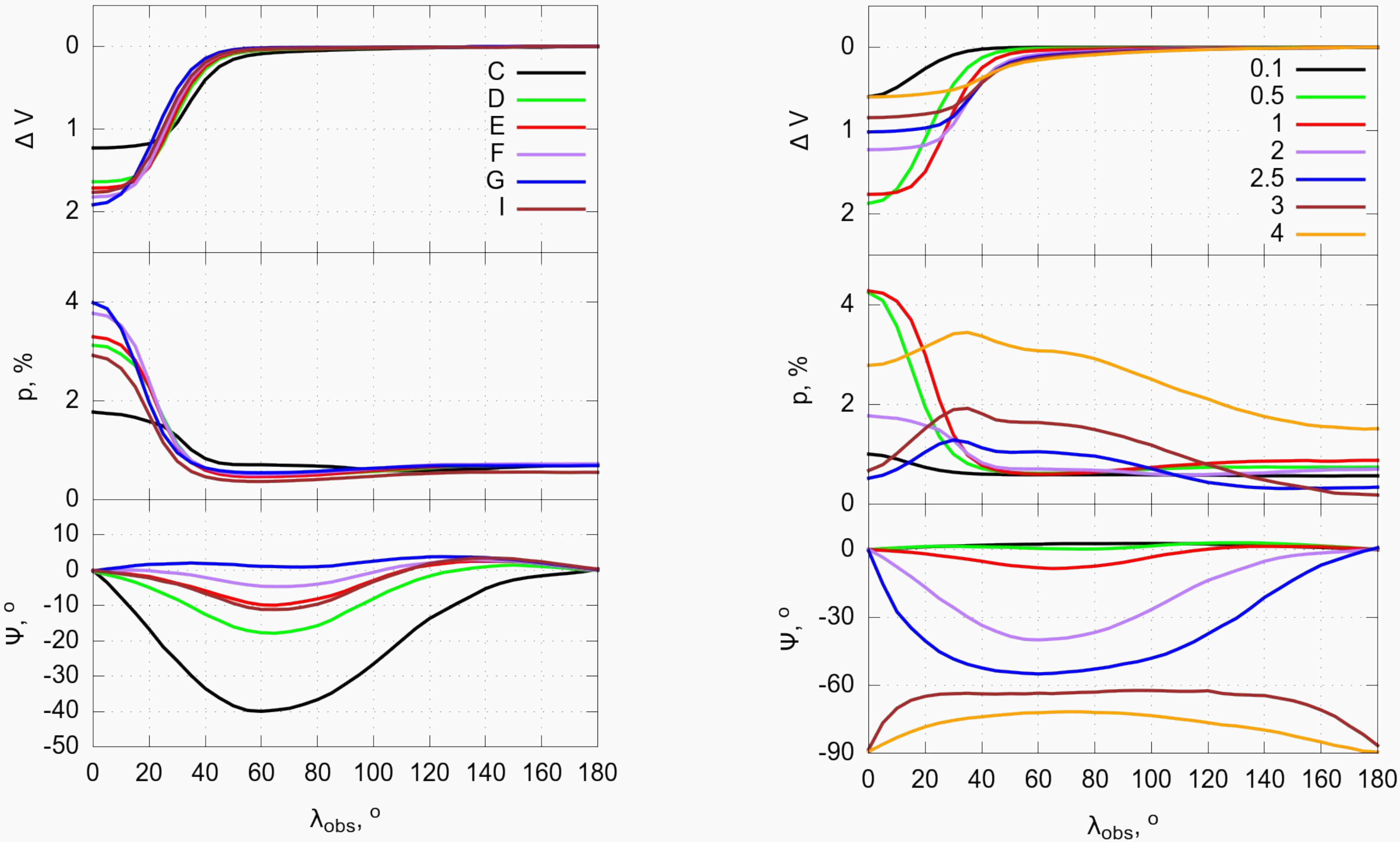
$$h(x,y) = h_0 \left(\frac{r}{R_0}\right)^{\beta} \left(1 + \frac{h_{hump}}{\sigma\sqrt{(2\pi)}} \exp\left(-\frac{(x - r_{hump})^2 + y^2}{2\sigma^2}\right)\right)$$






- Disk perturbation causes an eclipse and the change of the linear polarization positional angle
- Huge perturbations do not lead to the observed changes of the positional angle



ΔV
p, %
Ψ, o
λobs, o
C
D
E
F
G
I
0.1
0.5
1
2
2.5
3
4

# Results

- The perturbation of a thin disk leads to small changes of the linear polarization positional angle
- If the disk has a puffing up, the positional angle change may be up to 60º
- Thick disk may also have the linear polarization positional angle changes up to 30º
- The results depend on the puffing up model and wavelength significantly.

Thank you for attention!