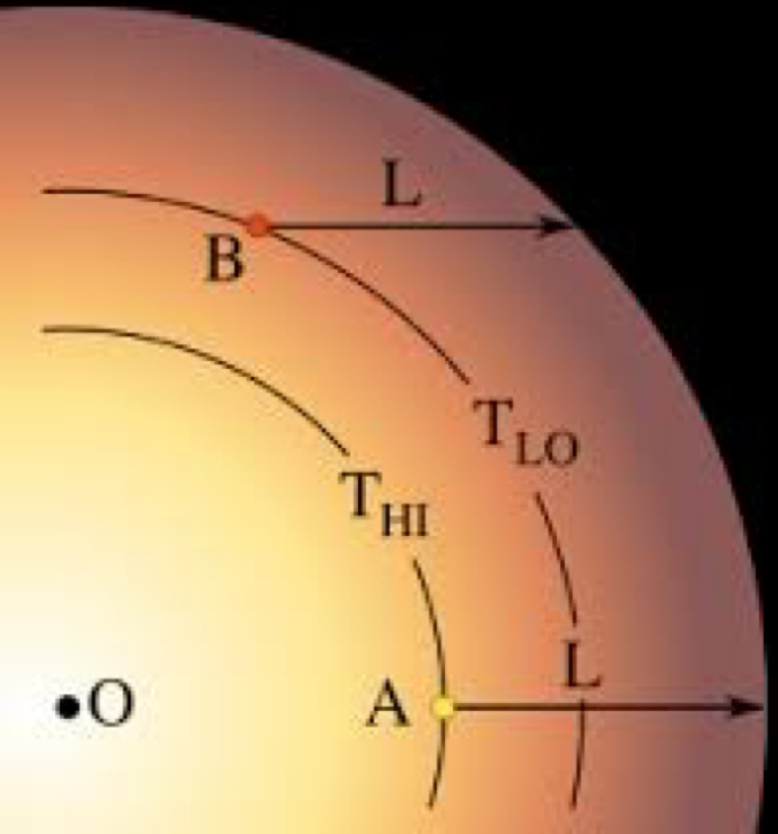
STELLAR LIMB DARKENING AND POLARIZATION: PROSPECTS FOR PLATO



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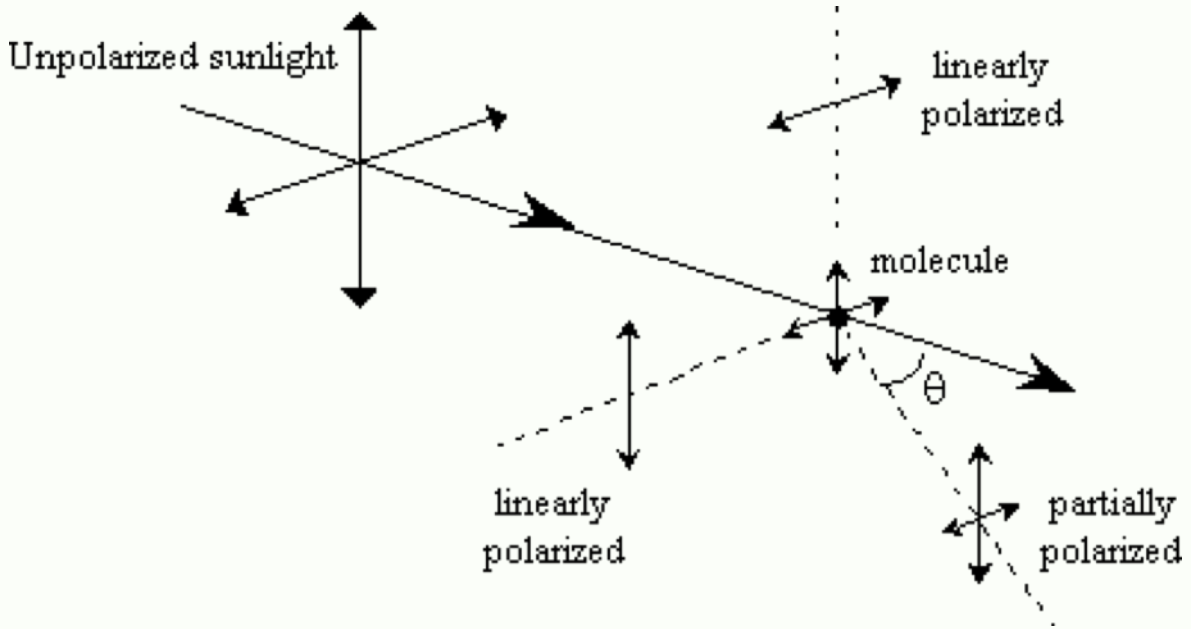
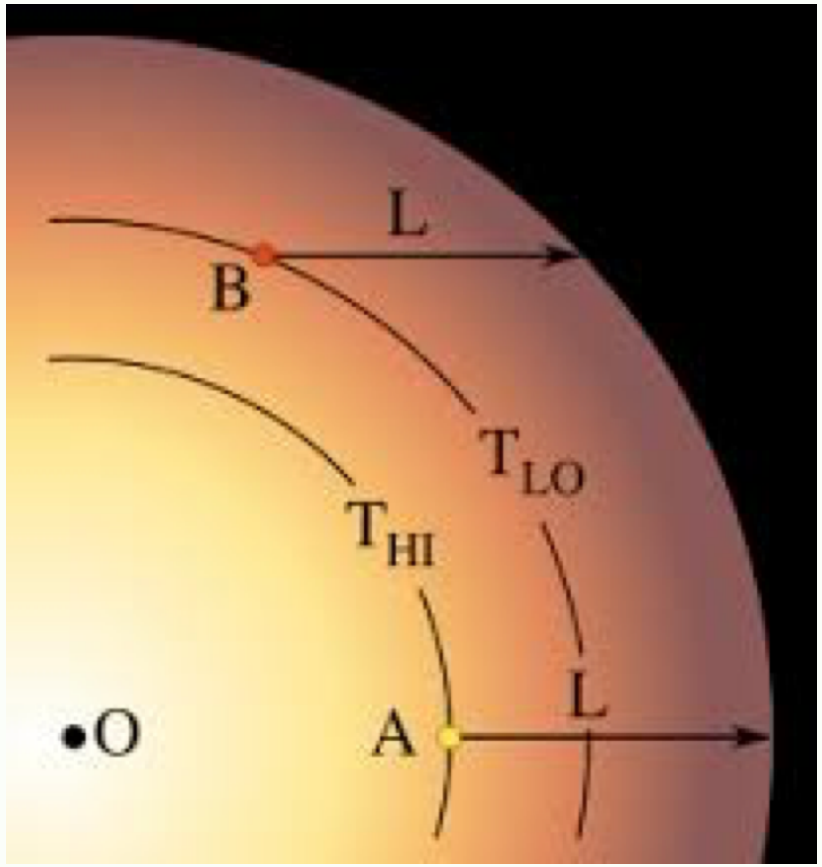
Introduction

Limb darkening and polarization

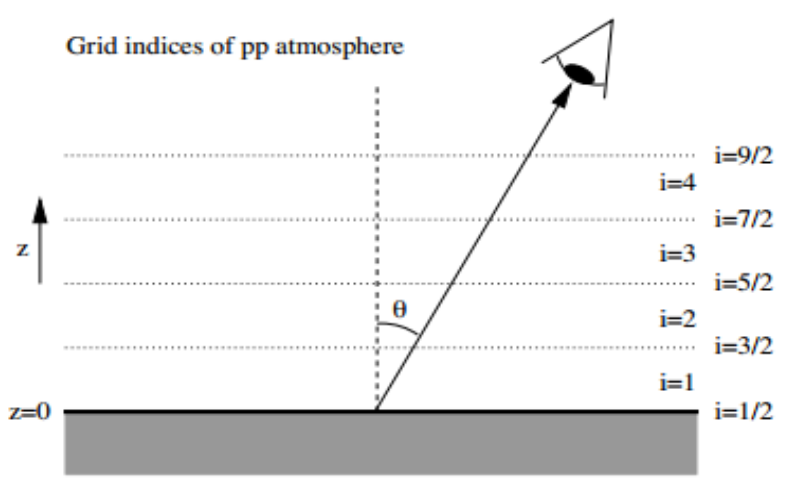




Inputs:

PP PHOENIX LTE models
(Hauschildt+, 1999)

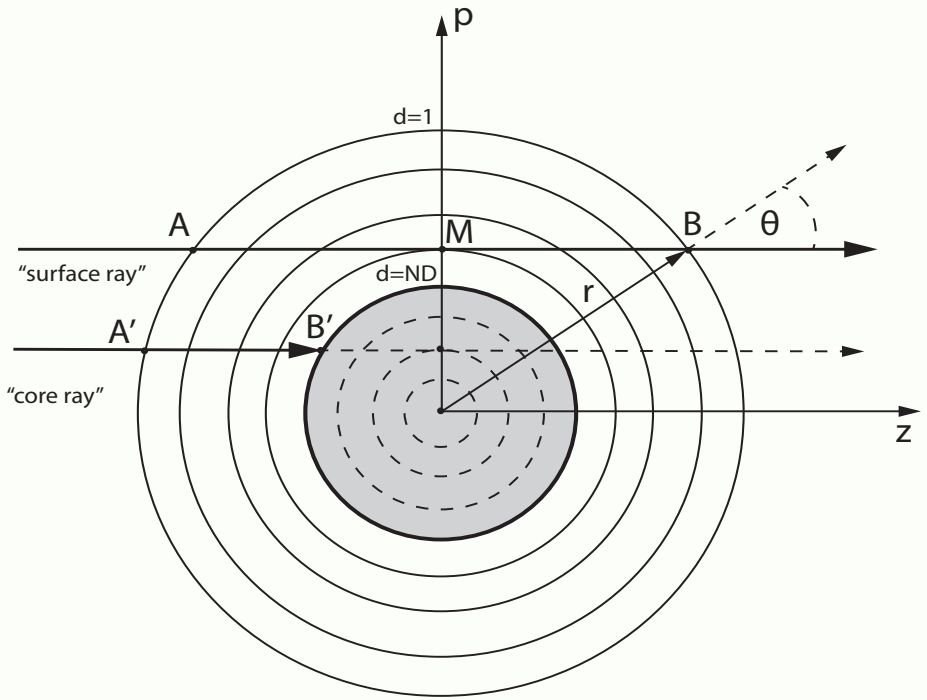
T_{eff} = 4000 – 6900 K
log g = 3.0 – 5.0



Kostogryz & Berdyugina 2015

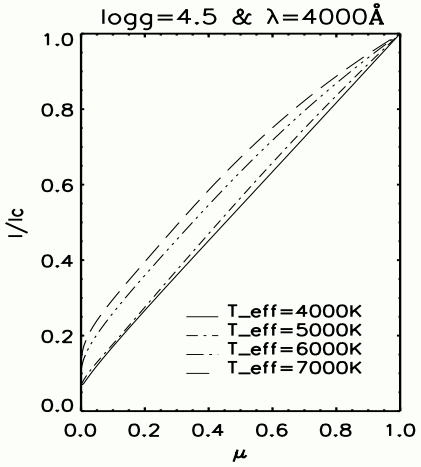
SpH PHOENIX LTE models
(Husser+, 2013)

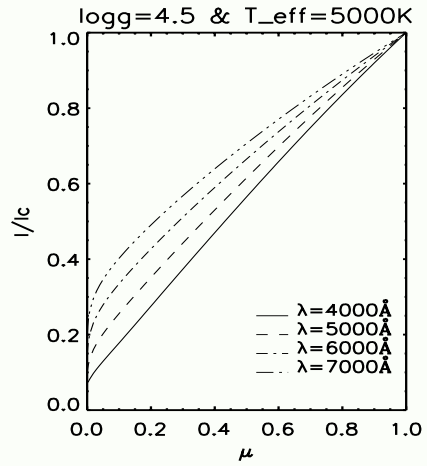
T_{eff} = 4000 – 7000 K
log g = 1.0 – 5.5

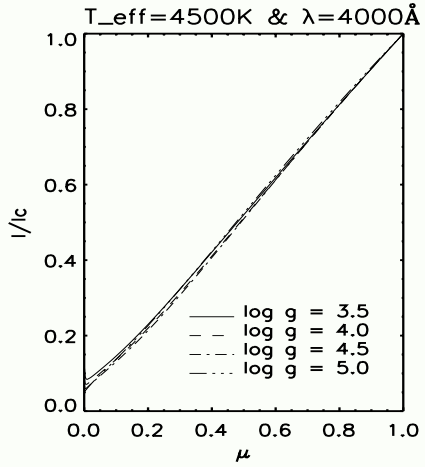


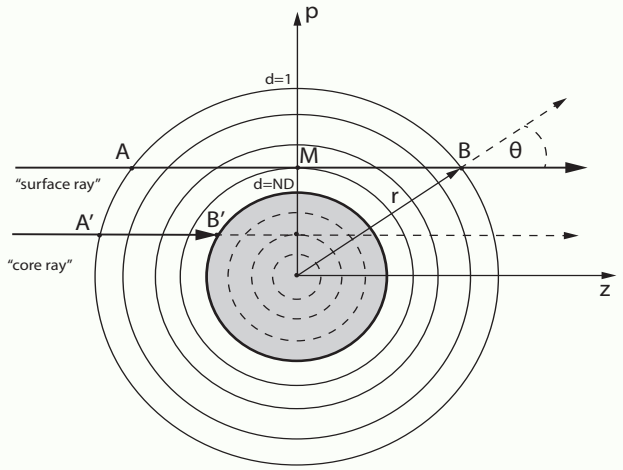
Kostogryz + 2016

Limb darkening



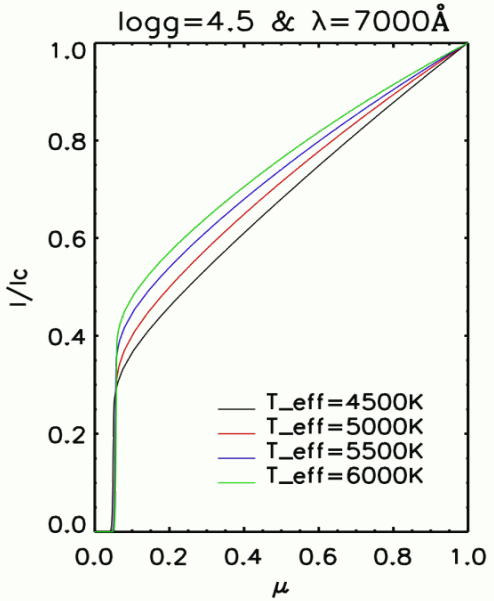


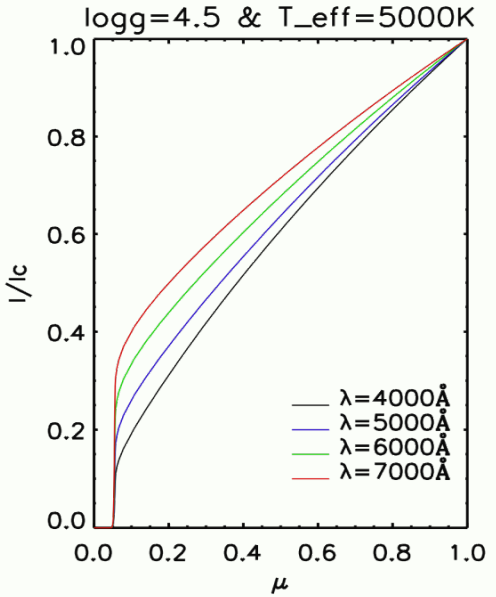


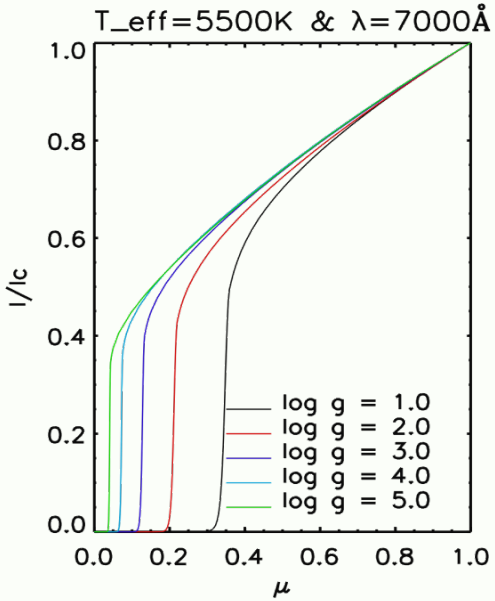


PLATO passband:
500-1000nm

Limb darkening for SphM atmosphere provides information about radius of the star

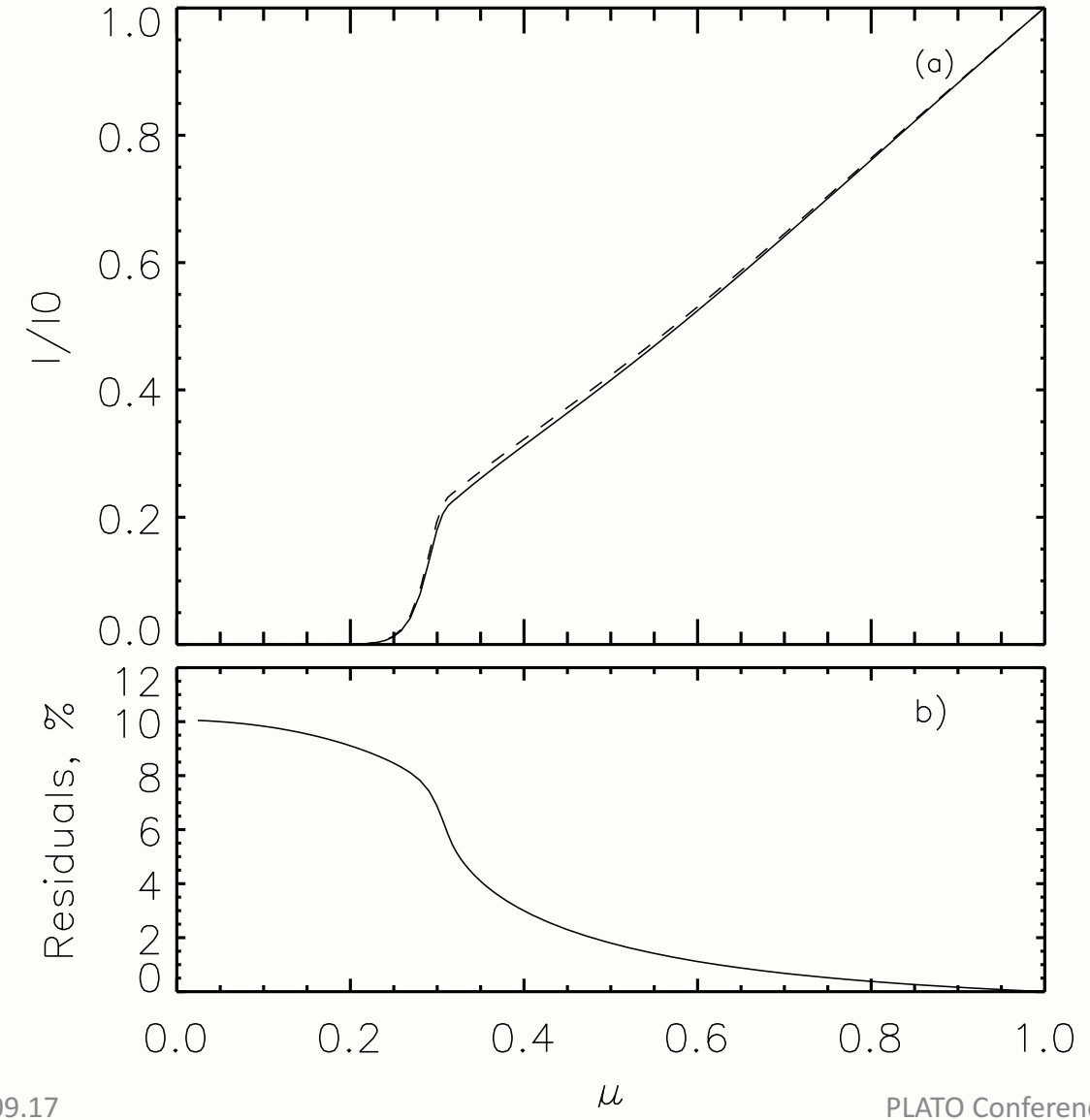






Kostogryz+ 2016

Limb darkening



T_{eff} = 4000 K, log g=1.5, $\lambda = 4000$ Å

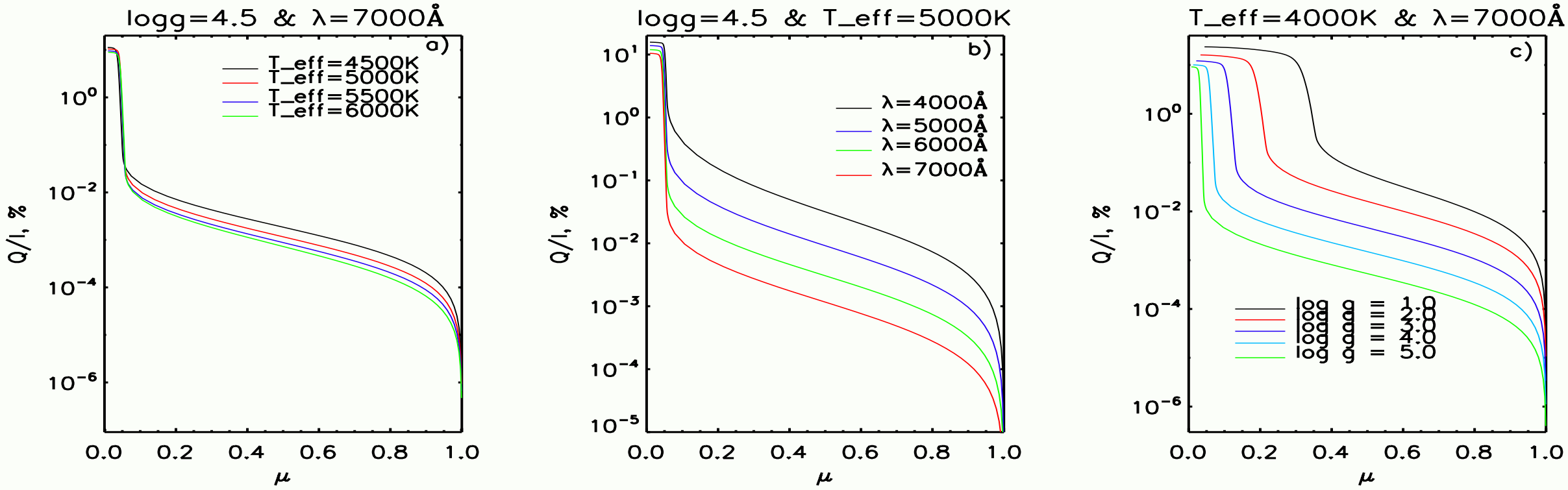
$$S_{sc}^{11} = \frac{1}{4\pi}\int (P_{11} \times I + P_{12} \times \mathrm{Q})\,\mathrm{d}\Omega'$$

Solid line – with polarization in RTE
Dashed line – neglecting polarization

Neglecting polarization in RTE leads up to 8% errors in intensity at the limb of stars.

Limb polarization

Kostogryz+ 2016

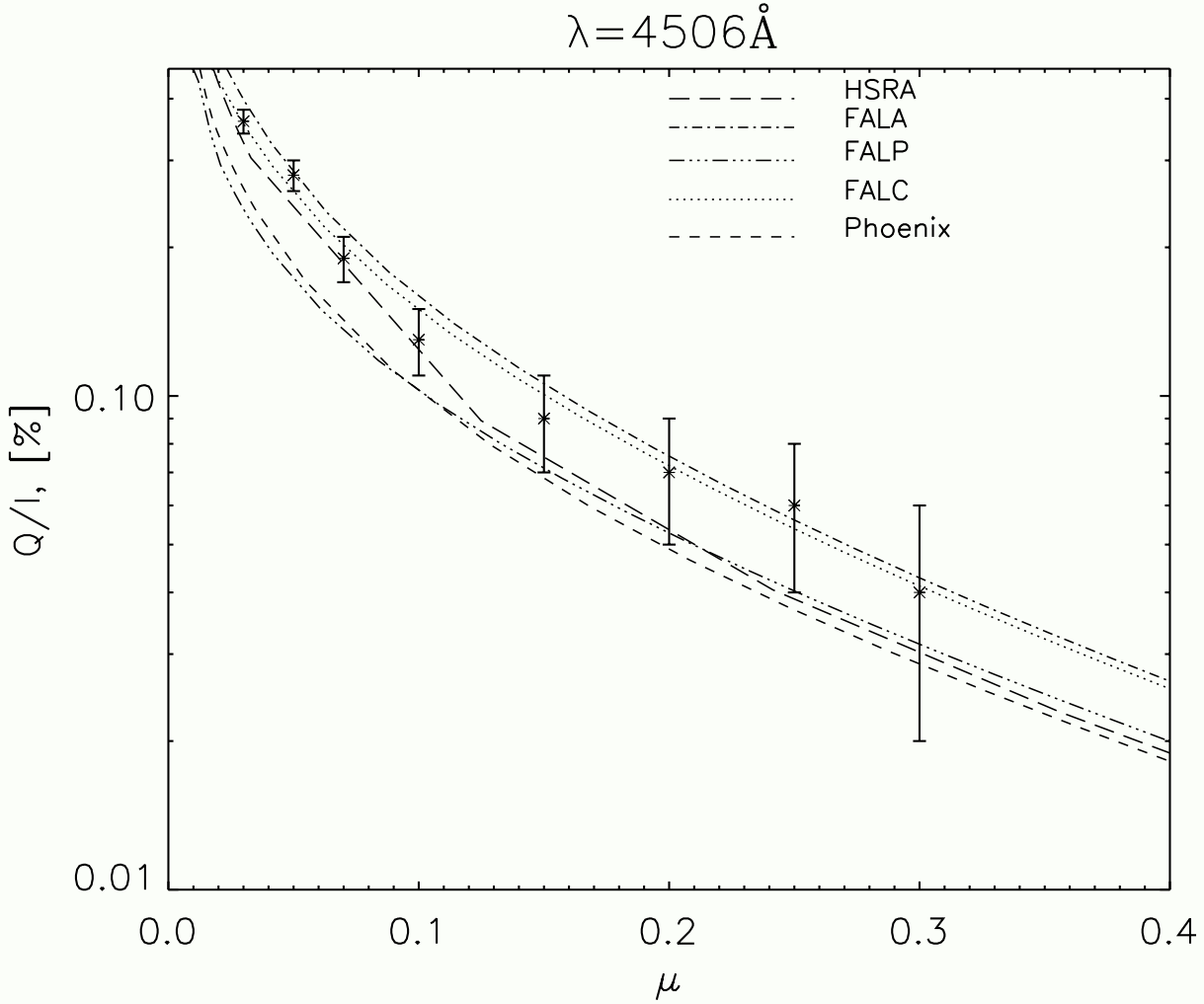


Sub-giant and dwarf stars (log g = 3.0 – 4.5):

lower gravity and Teff ➔ higher polarization

Solar limb polarization

Kostogryz+ 2016

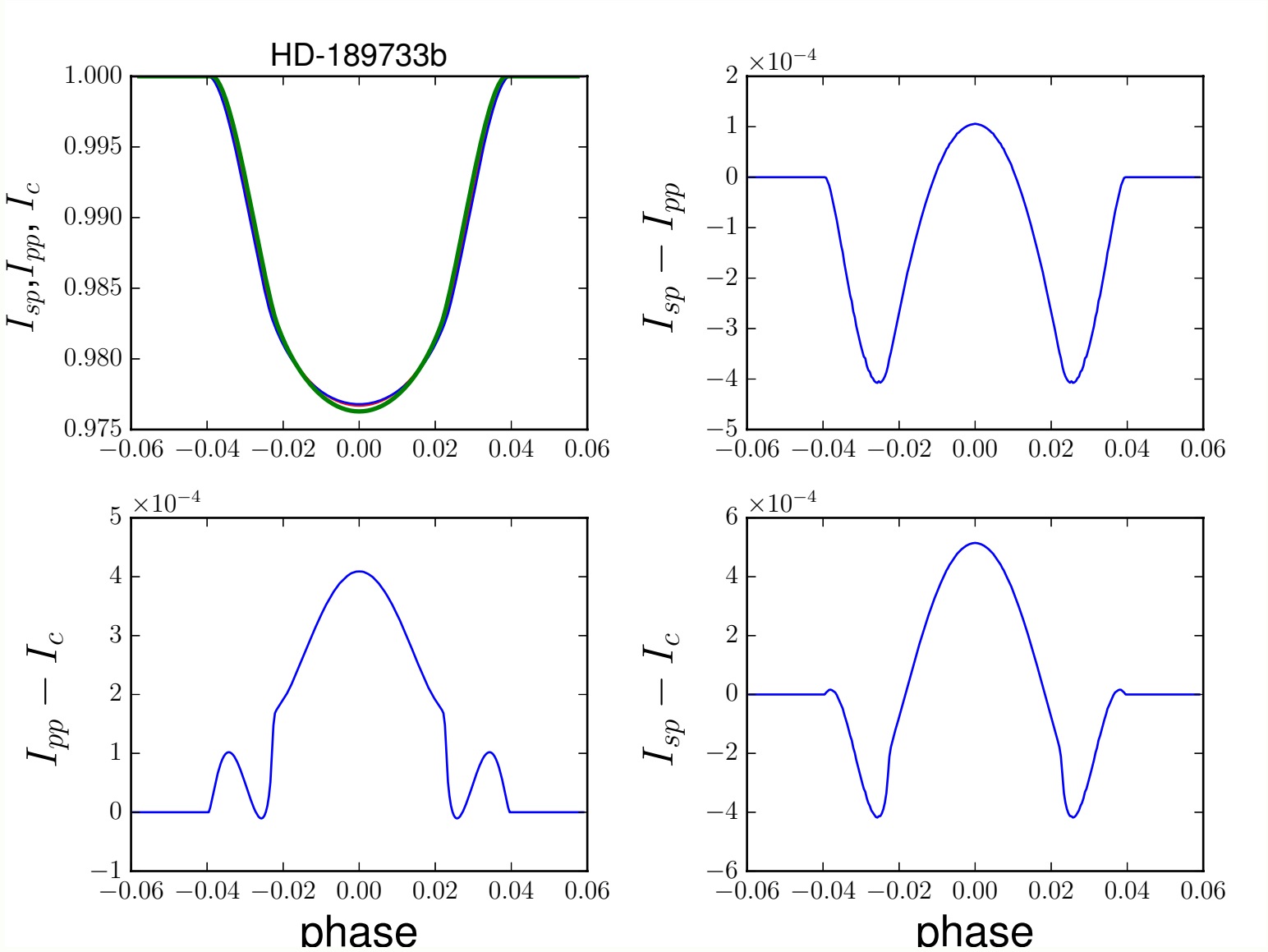


Solar limb measurements:
Wiehr & Bianda 2003

Limb polarization can be a good test of solar/stellar model atmospheres.

Transit curves

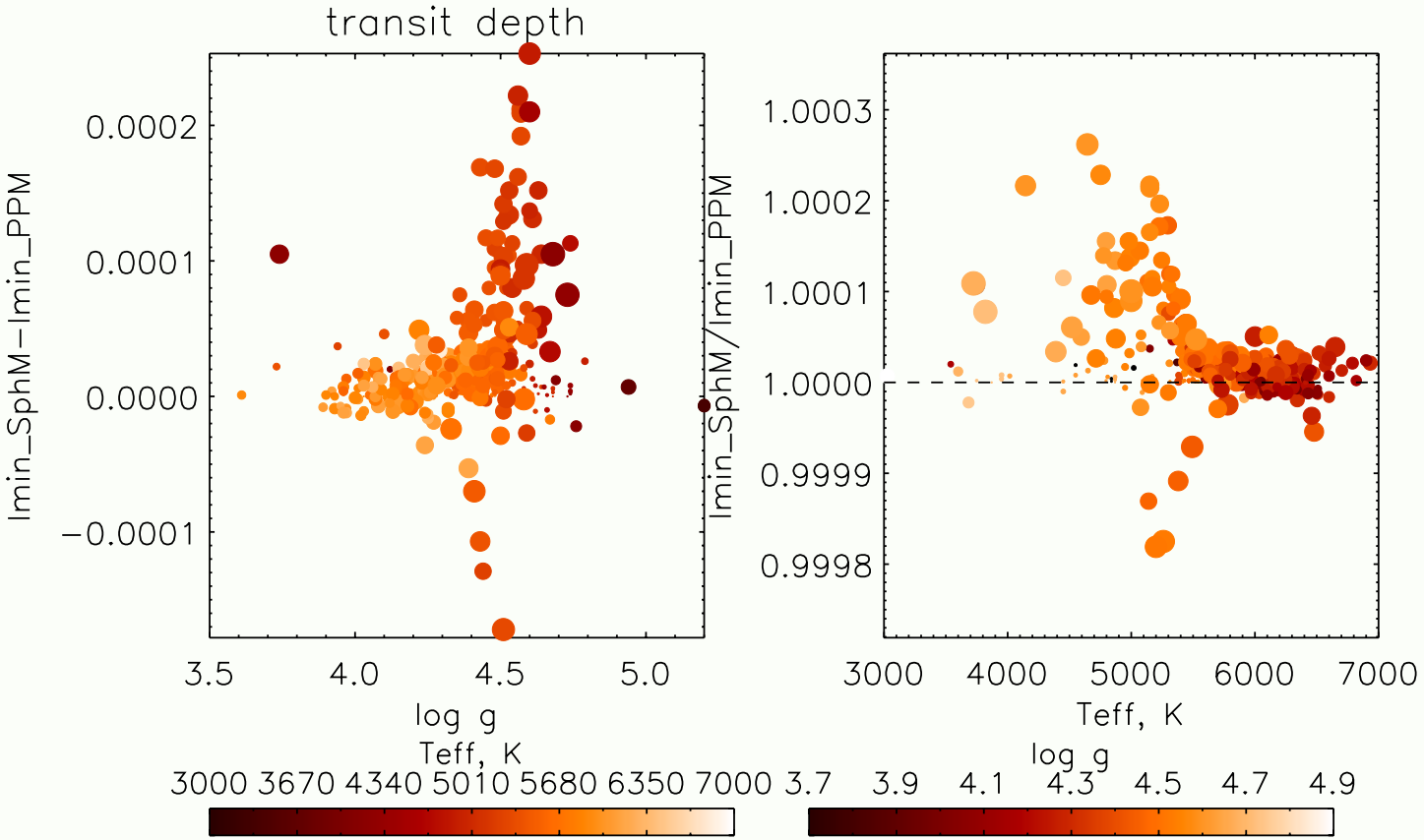
Transit depth differences

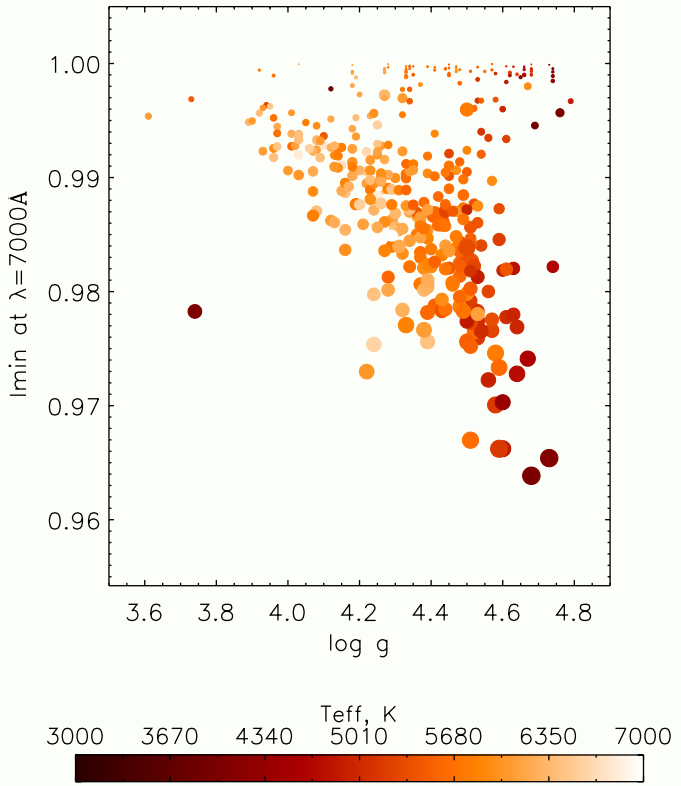


Ic → Claret 2011,
Ipp→ Kostogryz&Berdyugina 2015,
Isp → Kostogryz+ 2016

For accurate calculation of a transit curve, an accurate limb darkening calculations for spherical model atmosphere should be applied

Transit depth differences

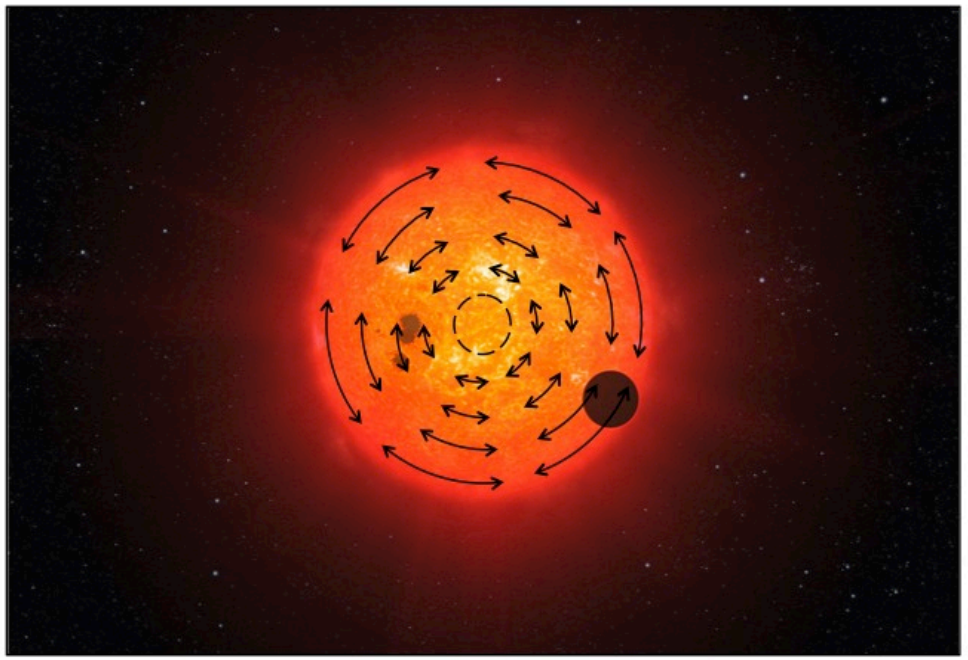


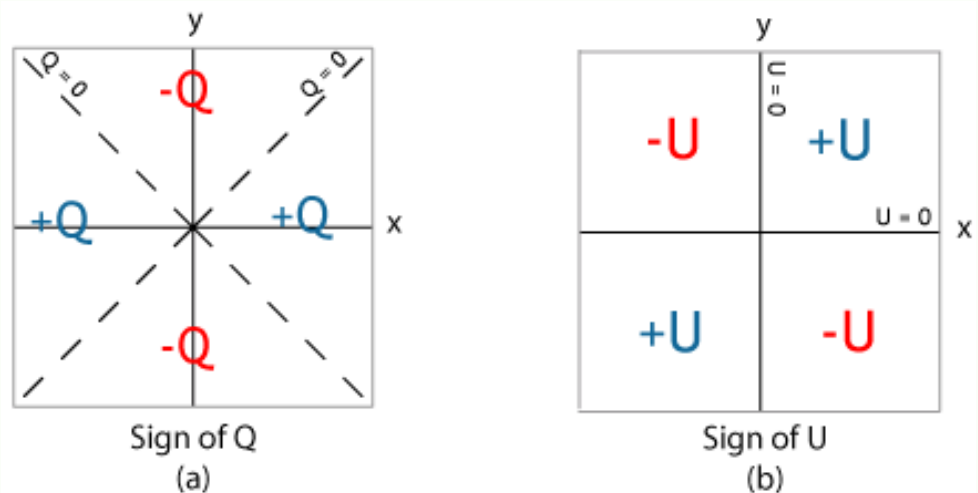


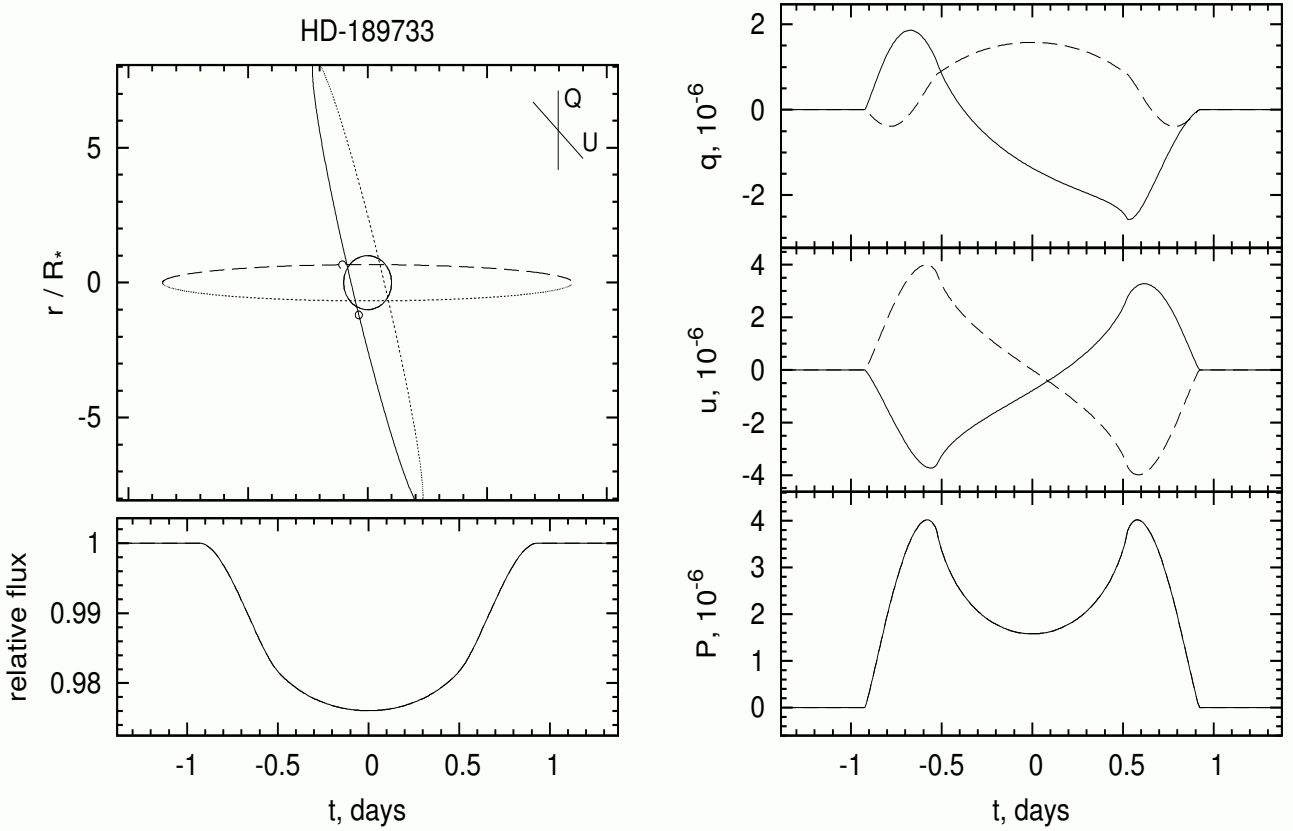
For stars with Teff <= 5500K and logg~4.5, the uncertainties in transit depth are about 10^{-4}

Transit polarization curves

Kostogryz+ 2015

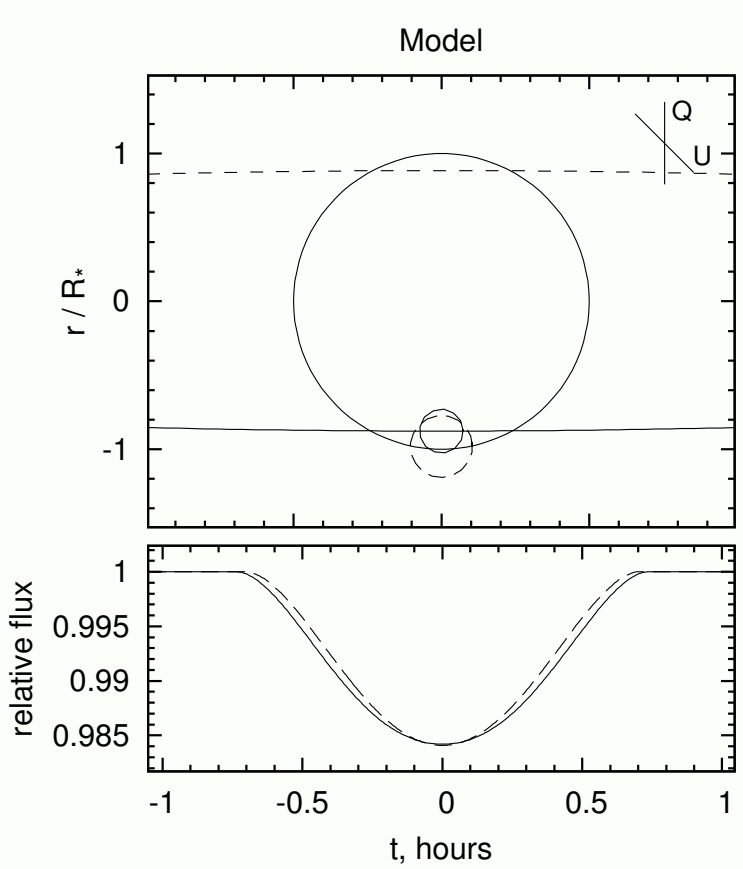


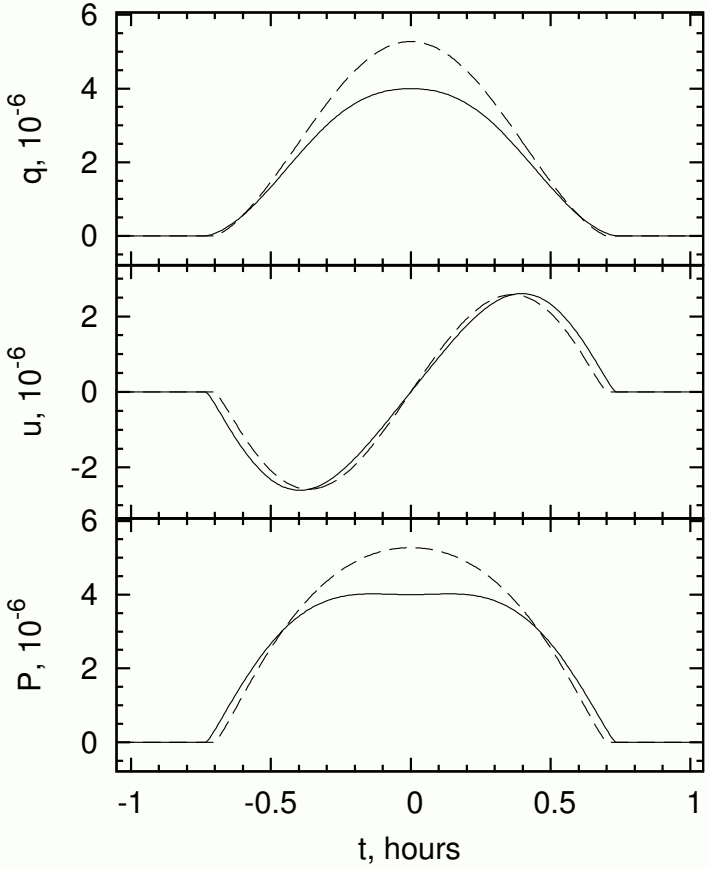




Transit polarimetry is sensitive to orientation of planet orbit in space

Grazing transit curves

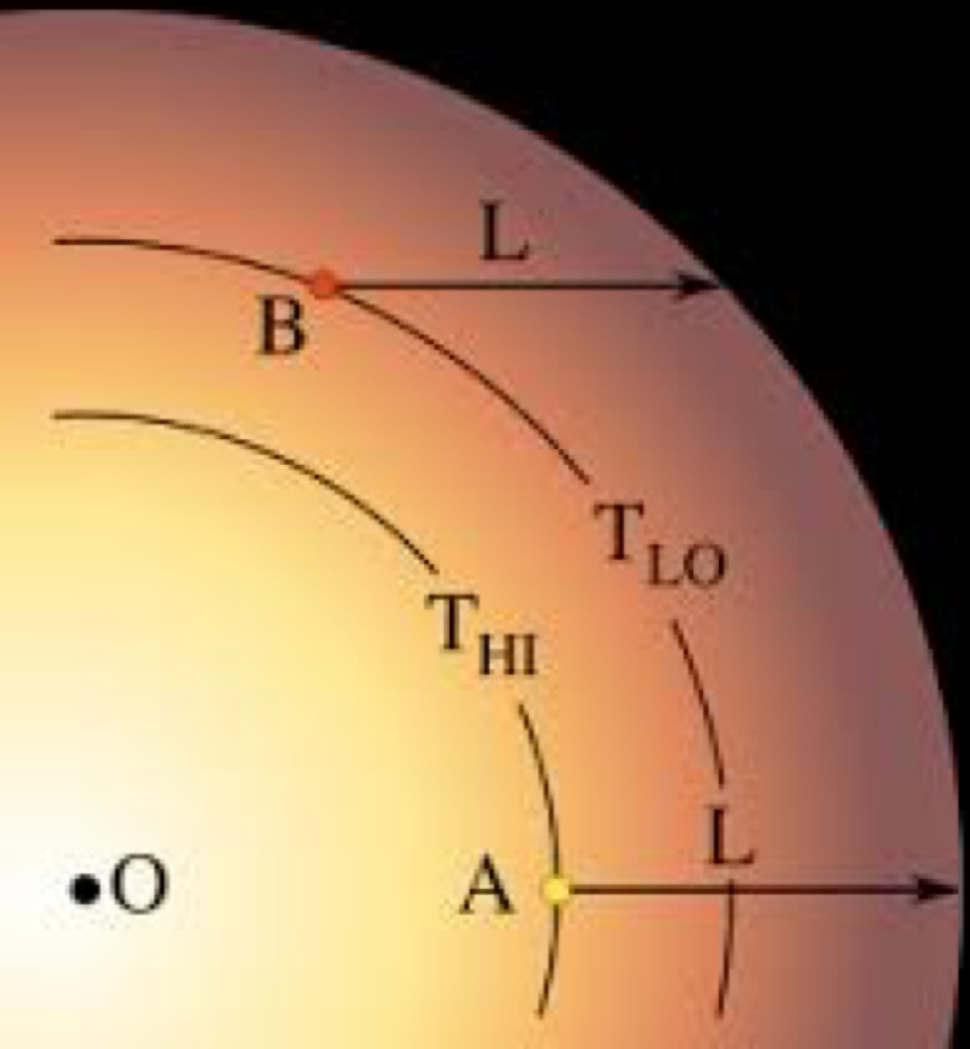




Transit polarimetry can help with planet radius estimation for grazing transits

Conclusions

- Accurate calculation of limb darkening needs polarization to be taken into account
- SphM is needed for calculations of transit curves ($\leq 3\times10^{-4}$). In other cases, PPM can be safely used.
- PLATO will provide lots of transit light curves that can be used to study limb darkening and test stellar models.
- Polarimetry of bright stars detected by PLATO can be used for follow-up observations.



Thank you for your attention

and to my collaborators:

Ivan Milic,
Taras Yakobchuk,
Peter Hauschildt