Multiwavelength modeling the SED of strongly interacting binaries

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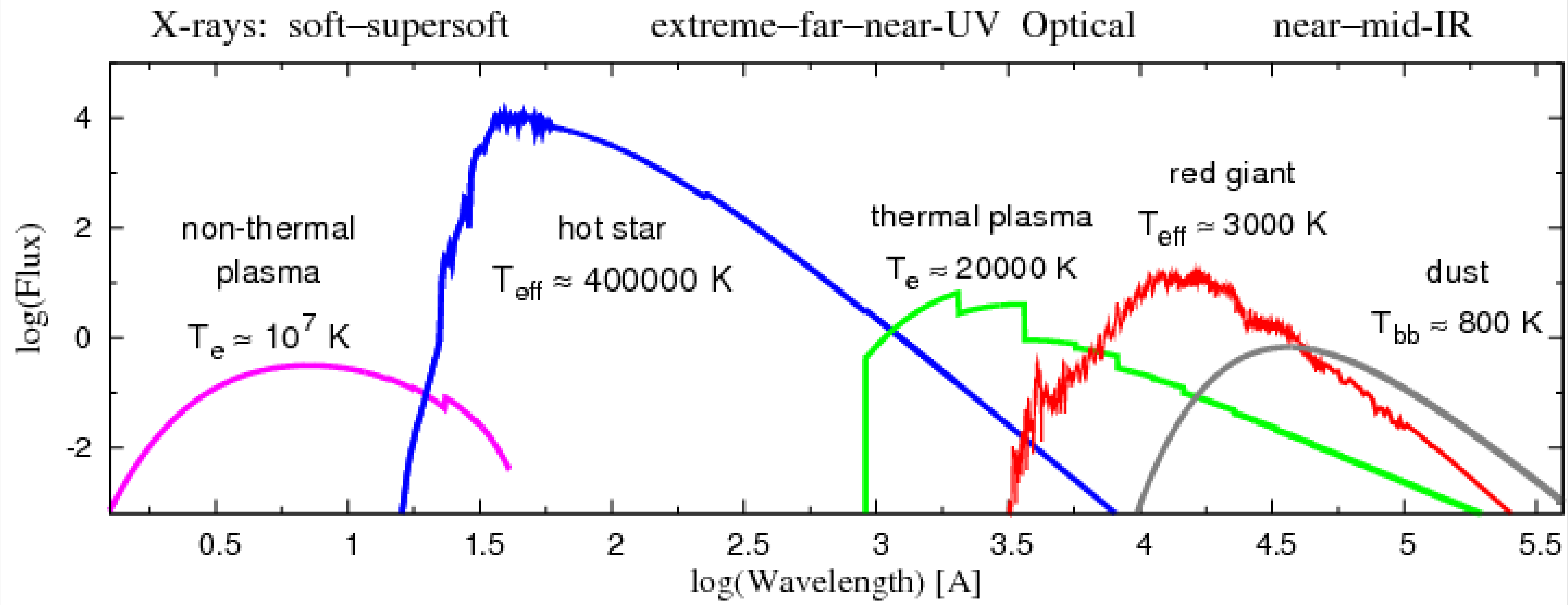
Composite spectrum of strongly interacting binaries.
(e.g. Super-soft X-ray sources, symbiotic (X-ray) binaries, novae)

Aim: to disentangle the composite spectrum $F(\lambda) = \sum_k F_k(\lambda, parameters)$



Method: Grid of models for physical parameters

N: $F_x(\lambda) = k_x \times \varepsilon_\lambda(T_e)\, E^{-\alpha} e^{-\beta E} e^{-\sigma_X N_H}$

Non-thermal plasma
($\varepsilon(\lambda, T)$ from Mewe et al. 1985)

H:
$$F_h(\lambda) \begin{cases} \theta_h^2 \pi B_\lambda(T_h)\, e^{-\sigma_X(\lambda) N_H} & \ldots \quad \lambda < 912 A \\ \theta_h^2 \pi B_\lambda(T_h)\, 10^{-0.4 R k_\lambda E_{B-V}} & \ldots \quad \lambda > 912 A, \end{cases}$$

$$\theta_h^2 = \left(\frac{R_h^{eff}}{d}\right)^2$$

Hot star

N: $F_n(\lambda) = k_n \times \varepsilon_\lambda(H, He^+, T_e, a),$

$$k_n = \frac{EM}{4\pi d^2} \quad [cm^{-5}]$$

Thermal plasma

G: $F_g(\lambda) = \theta_g^2 F_g^{synth.}(\lambda, T_{eff})$

$$\theta_g^2 = \left(\frac{R_g}{d}\right)^2$$

Cool giant

D: $F_d(\lambda) = \theta_d^2 \pi B_\lambda(T_{bb})$

$$\theta_D^2 = \left(\frac{R_D^{eff}}{d}\right)^2$$

Dust

$\chi^2 - criterion$

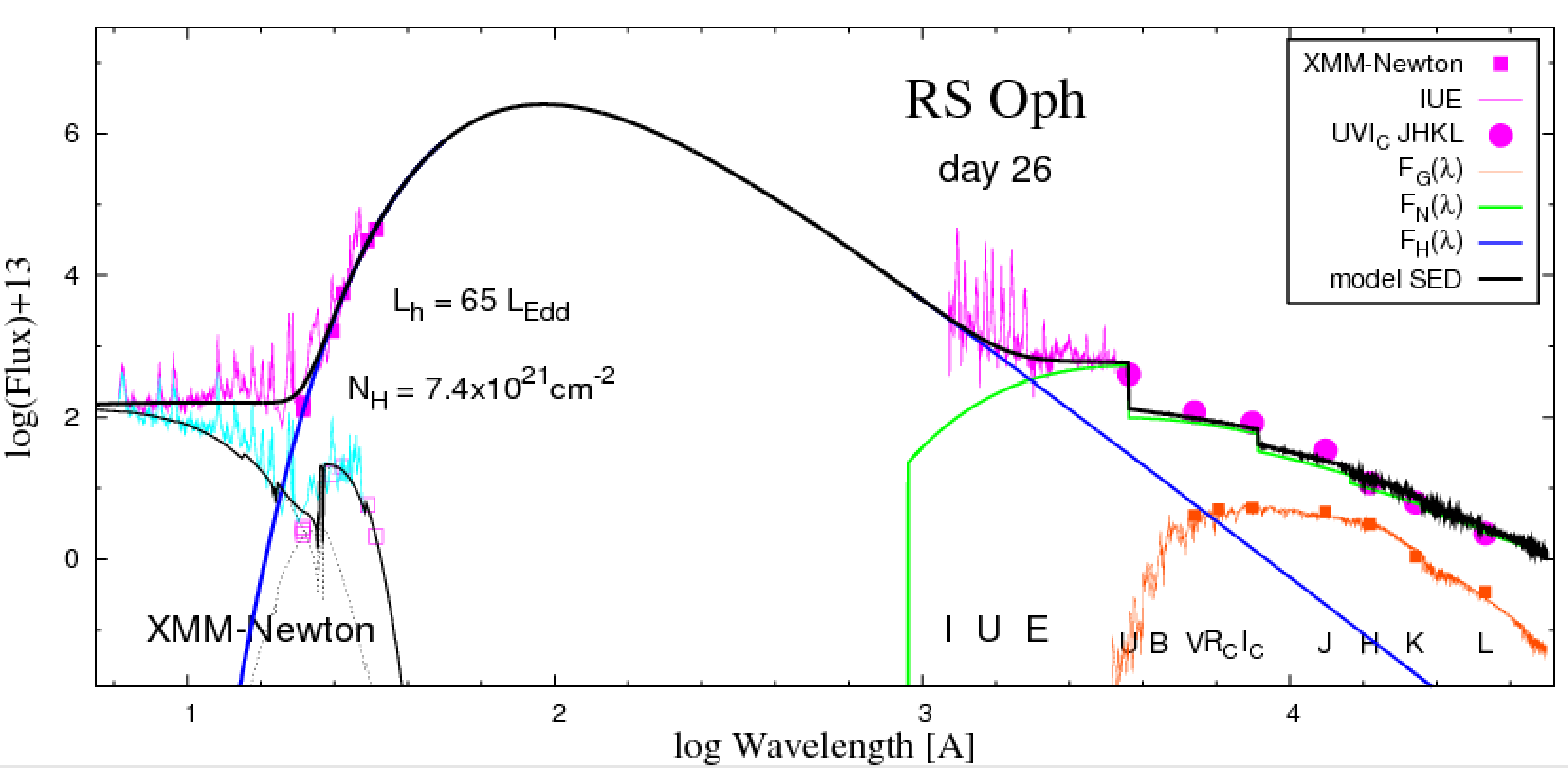
INPUT: λ, F_λ, F_λ^{err}, → OUTPUT: physical parameters

Method: Skopal (2005); Skopal et al. (2009)

Recurrent symbiotic nova RS Oph: day 26

Recent outbursts: 1985 January 26; 2006 February 12

d = 1.6 kpc



Hot star:

$N_H \sim 7.4\times10^{21}\,\mathrm{cm}^{-2}$

$T_h \sim 310{,}000\,\mathrm{K}$

$R_h \sim 0.6 R_{\mathrm{Sun}}$

$L_h \sim 64 L_{\mathrm{Edd}}$

Nebula:

$EM \sim 6.2\times10^{61}\,\mathrm{cm}^{-3}$

$T_e \sim 20{,}000\,\mathrm{K}$

Giant:

$T_{eff} = 4100\,\mathrm{K}$

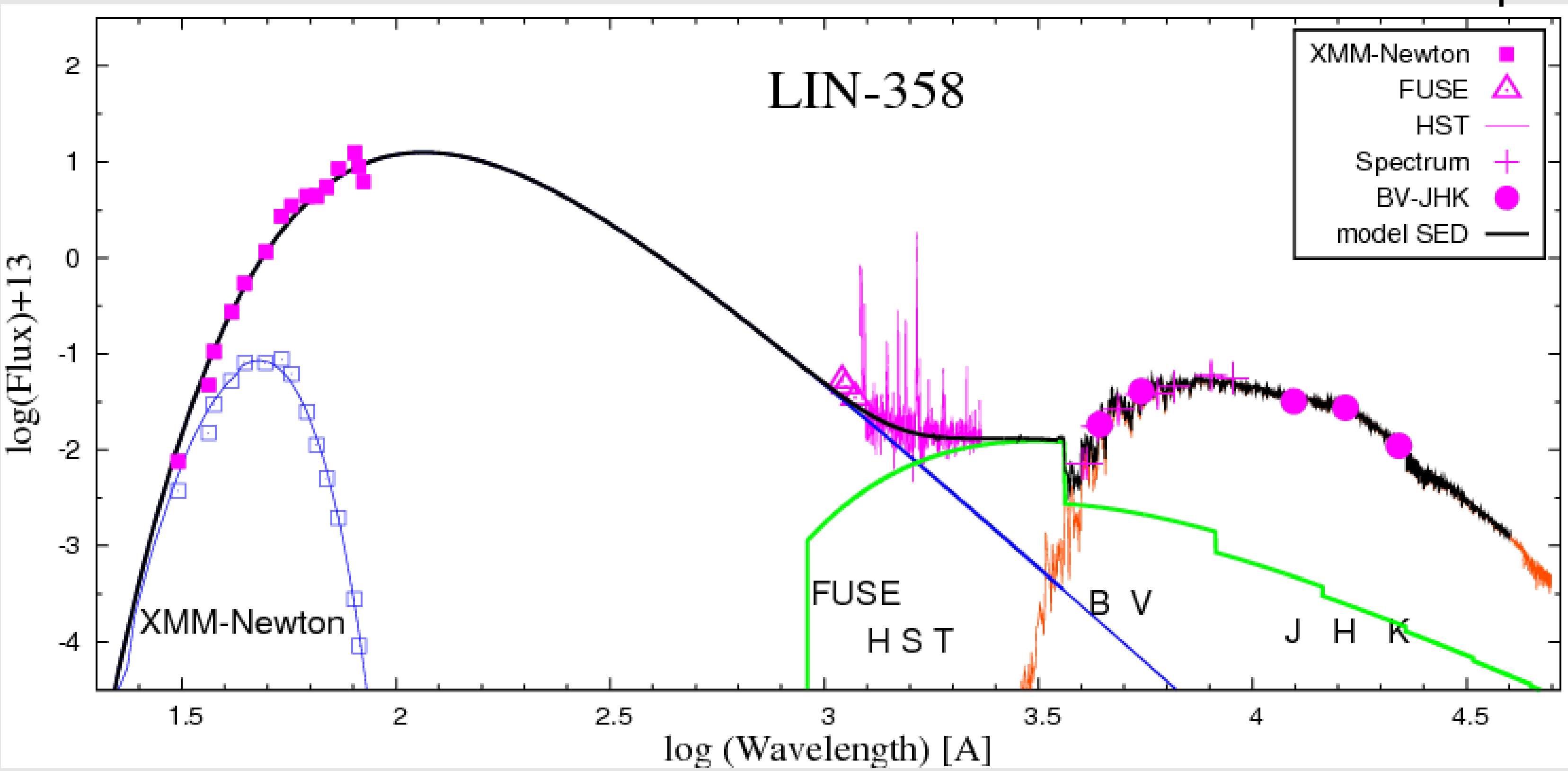
$R_G = 47 R_{\mathrm{Sun}}$

$L_G = 560 L_{\mathrm{Sun}}$

Skopal (2011, in preparation)

Symbiotic X-ray binary LIN-358 (in SMC)

d = 60 kpc



Hot star:

$N_H \sim 5.9\times10^{20}\,\mathrm{cm}^{-2}$

$T_h \sim 250{,}000\,\mathrm{K}$

$R_h \sim 0.081 R_{Sun}$

$L_h \sim 8.9\times10^{37}\,\mathrm{erg/s}$

Nebula:

$EM \sim 2.2\times10^{60}\,\mathrm{cm}^{-3}$

$T_e \sim 23{,}000\,\mathrm{K}$

Giant:

$T_{eff} = 4000\,\mathrm{K}$

$R_G = 180 R_{Sun}$

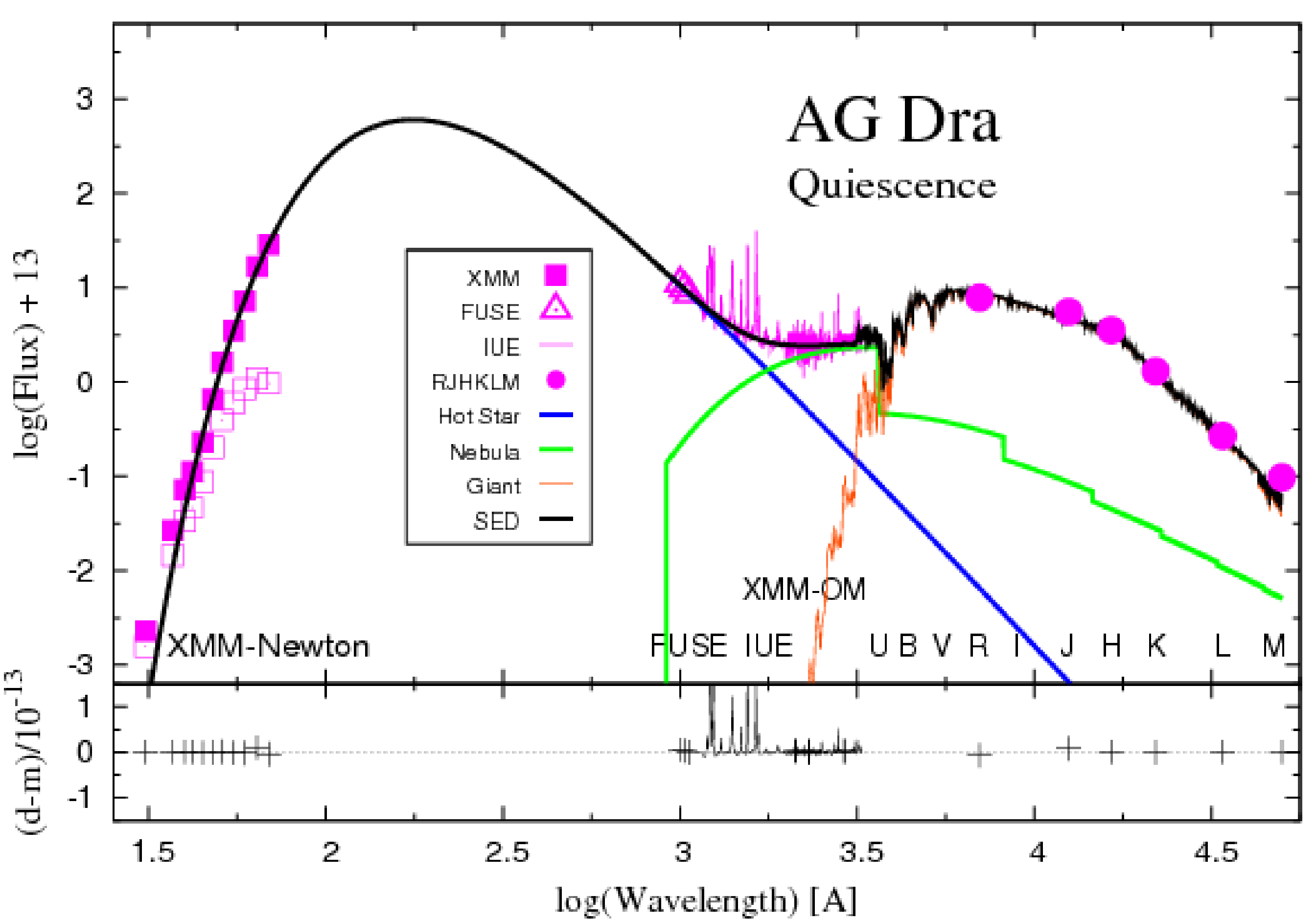
$L_G = 6800 L_{Sun}$

Skopal (2011, in preparation)

Classical symbiotic star AG Dra

Quiescent phase

d = 1.1.kpc



Hot star:

$L_h = 630 L_{Sun}$

$T_h = 165{,}000\,K$

$R_h = 0.03 R_{Sun}$

$N_H = 3.13 \times 10^{20}\,cm^{-2}$

Nebula:

$EM = 1.3 \times 10^{59}\,cm^{-3}$

$T_e = 21{,}000\,K$,

Giant:

$L_G = 360 L_{Sun}$

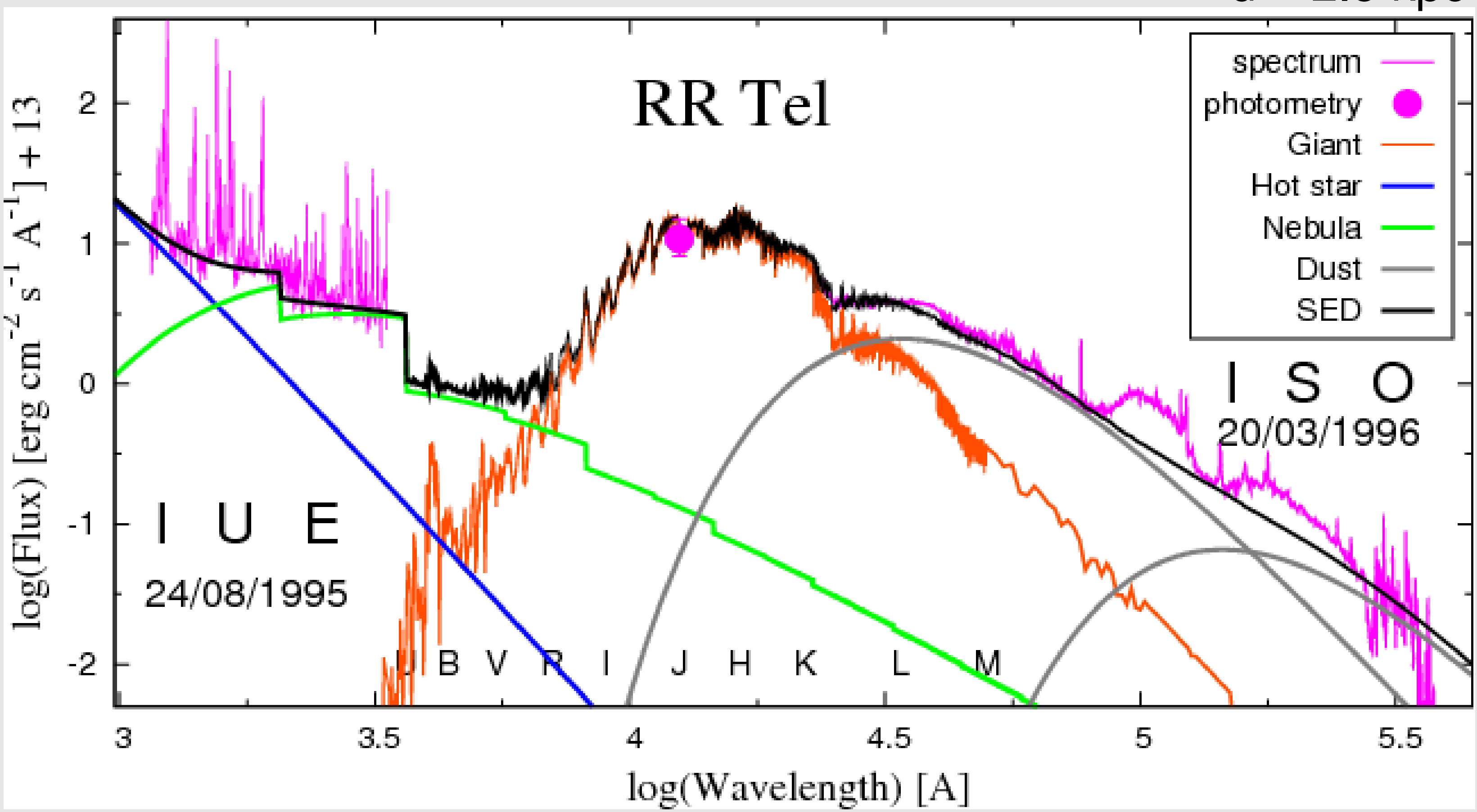
$T_{eff} = 4300\,K$

$R_G = 33 R_{Sun}$

Adapted according to Skopal et al. 2009, A&A, 507, 1531

Symbiotic nova RR Tel

d = 2.5 kpc



Hot star:

$L_h = 4400 L_{Sun}$

$T_h = 150{,}000K$

$R_h^{eff} = 0.1 R_{Sun}$

Nebula:

$EM = 8.0 \times 10^{59}\,cm^{-3}$

$T_e = 26{,}000K$,

$a(HeII) \sim 0.08$

Giant:

$L_G = 3700 L_{Sun}$

$T_{eff} = 2700K$

$R_G = 280 R_{Sun}$

Dust:

$L_D = 2100 L_{Sun}$

$T_D = 850K$

$R_D^{eff} = 2100 R_{Sun}$

(Credit: A. Skopal, not published)

Concluding remarks

Multiwavelength modeling the SED

1. Basic physical parameters of radiative components
2. Ionization structure of the binary during active phases
3. A mechanisms driving the outburst
4. Nature of accretors