Properties of synthetic blazar radio light curves

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Introduction

Blazars are among the most powerful extragalactic objects, as a sub-class of active galactic nuclei. They launch relativistic jets and their emitted radiation shows strong variability across the entire electromagnetic spectrum. The mechanisms producing the variability are still controversial and different models have been proposed to explain the observed variations in multi-frequency blazar light curves.We investigate the capabilities of the classical shock-in-jet model to explain and reconstruct the observed evolution of flares in the turnover frequency – turnover flux density (ν_m–S_m) plane and their frequency-dependent light curve parameters.

Shock-in-Jet Model

The model assumes that a shock wave propagates through a conical jet and accelerates particles at the shock front. These particles radiate energy through different channels, namely Compton, synchrotron and adiabatic losses, which lead to an increase in the observed emission (Marscher & Gear 1985, Tuerler 2000, Fromm et al. 2011). The energy distribution of the relativistic electrons is assumed to be a power-law $N(E) = KE^{-s}$, with K the normalisation coefficient, E the energy, and s the spectral slope. The evolution of the physical parameters, e.g., the magnetic field, B, the normalisation coefficient K, and the Doppler factor, δ, in the bulk flow are parametrized by

$$B \propto R^{-b} \quad K \propto R^{-k} \quad \delta \propto R^{-d}$$

The evolution of a flare can be modelled by the exponents, s,b,k, and d. (For more details see Fromm et al. 2014)

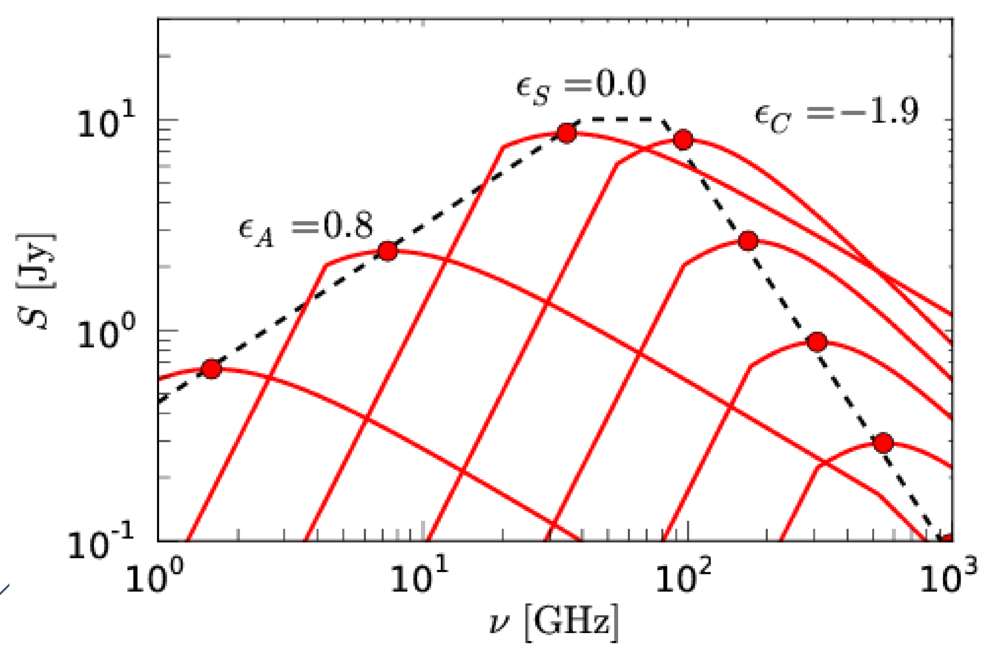

Fig 1: Spectral evolution of flare in the turnover frequency— turnover flux density plane

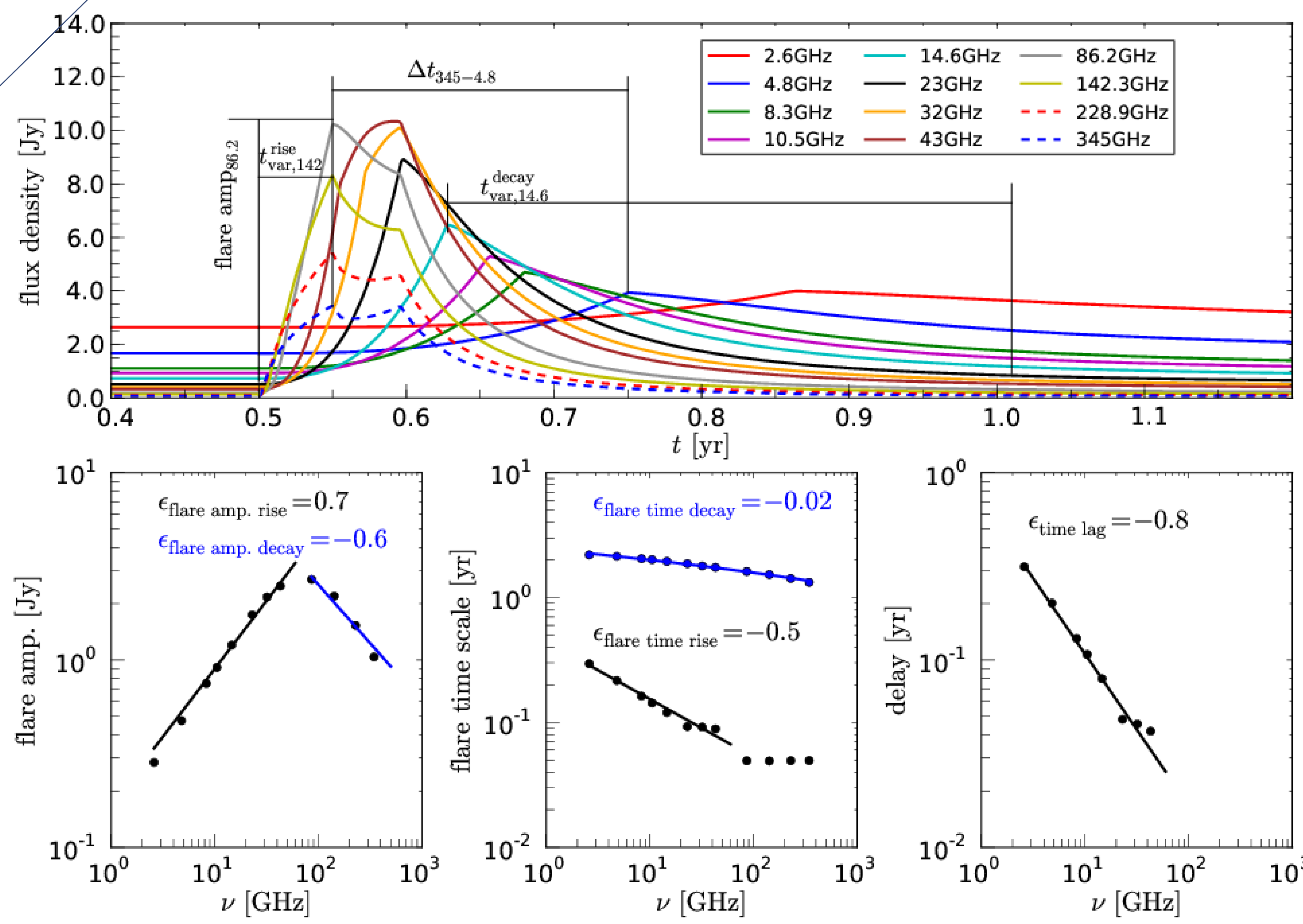

Fig 2: Synthetic single-dish light curves (top) and light curve analysis from left to right flare amplitudes, flare time scales and cross-band delay

Parameter Space Studies

We investigate the variation in the slopes of the different energy loss stages and of the light curve parameters for a large parameter space:

b	s	k	d
1 – 2	2– 3	2.7 –3.3	-0.45 – 0.45

For each set of parameters we compute the spectral evolution and extract the single dish light curve parameters (see Fig. 3 for d=0.45)

Shock identification guide

Several single dish light curves and large frequency coverage:

- create simultaneous spectra from light curve
- fit synchrotron self-absorbed spectrum to data
- fit power laws to the evolution of the turnover frequency and flux density
- compare slopes with parameter space studies

Few single dish light curves and small frequency coverage:

- obtain flare amplitudes, flare time scale and cross band delay
- fit power laws to the obtained single dish light curve parameters
- compare slopes with parameter space studies

Conclusion

Our results can be used to constrain the physical properties of jets and their evolution within the collimation and acceleration regions, by comparison with detailed multi-frequency monitoring observations of blazar radio flares.Taking advantage of the broad-band (2.6 to 345 GHz), F-GAMMA monitoring program, we plan to apply this model to a large number of blazar flares to constrain the jet and/or flare properties. The parameters obtained can be used as initial conditions in more advanced shock models, including the relativistic magneto-hydrodyamic nature of jets to further investigate the physics of blazars.

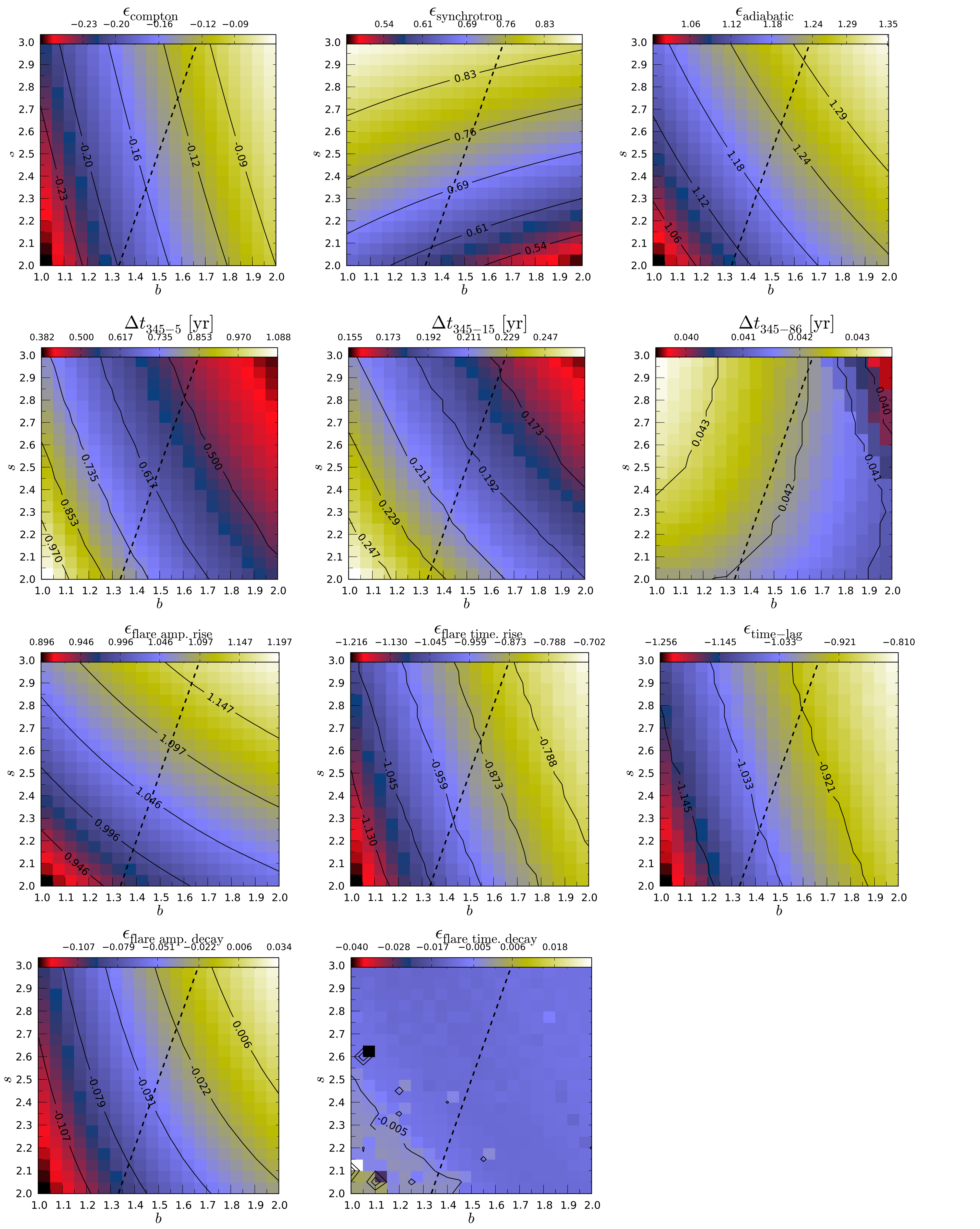

Fig 3: Parameter space plot for a model with d=0.45. From top to bottom slopes of the different energy loss stages, time lags, light curve parameters obtained from the rising edge of the light curves and from the decaying edge of the light curves

References

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