Modelling Spatial and Temporal Emission Properties of the Young Pulsar Wind Nebula Kes 75

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INTRODUCTION AND MODEL

Kes 75 is one of the youngest composite supernova remnants, containing the pulsar wind nebula (PWN) of young glitching PSR J1846−0258, which exhibited magnetar-like outbursts in 2006.

We use a spatio-temporal leptonic emission code that calculates relativistic particle injection, transport, and emission as these particles traverse a PWN [3] – this is referred to as the *old model*.

The *new model* attempts to simulate the energy release from the magnetar-like bursts, by increasing bulk motion of particles to 10 times its previous value, but only for the last 50 years of the current age of the nebula. Parametrisation for the diffusion coefficient is considered to be a power law in the *new model*, with no dependence on time or space. Different best-fit model parameters are summarised in the table below.

Fixed parameters	Old model		New model	
Pulsar period (P) (s)	0.324		0.324	
Time-derivative of period ($\dot{P}$) (s s^{-1})	7.1×10^{-12}		7.1×10^{-12}	
Spin-down luminosity ($L_{\rm age}$) (erg/s)	8.2×10^{36}		8.2×10^{36}	
Braking index (n)	2.16		2.16	
Distance to the source (kpc)	6.0		6.0	
Index of the injected spectrum (α_1)	1.4		1.4	
Index of the injected spectrum (α_2)	2.3		2.3	
Break energy ($\gamma_{\rm b}$)	2.0×10^5		6.0×10^5	
Magnetic energy conversion efficiency (η)	0.01		0.01	
Particle energy conversion efficiency (ϵ)	0.99		0.99	
Sigma parameter (σ)	0.01		0.01	
Magnetic field time dependence ($\beta_{\rm B}$)	−1.0		−1.0	
Soft-photon components:	T (K)	u (eV/cm^3)	T (K)	u (eV/cm^3)
Cosmic microwave background (CMB)	2.76	0.23	2.76	0.23
Infrared	25.0	2.5	15.0	0.8
Optical	5000	1.4	5000	1.4

Fitted parameters	Old model	New model
Radial parameter of the magnetic field ($\alpha_{\rm B}$)	0.0	1.0
Present-day magnetic field (μG)	11	205
Bulk flow normalisation (10^{10} cm s^{-1})	0.012	0.012
Age (yrs)	700	700
Diffusion coefficient normalisation (κ_0)	0.33	

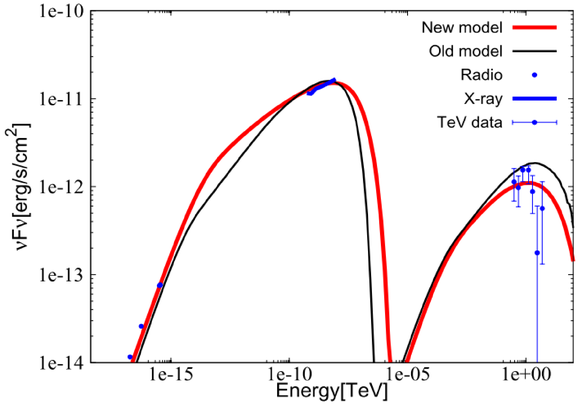

Figure 1. Predicted spectral energy density (SED) for Kes 75 shown for old (in black) and new (in red) model. Radio, X-ray, and VHE observational data are taken from [1].

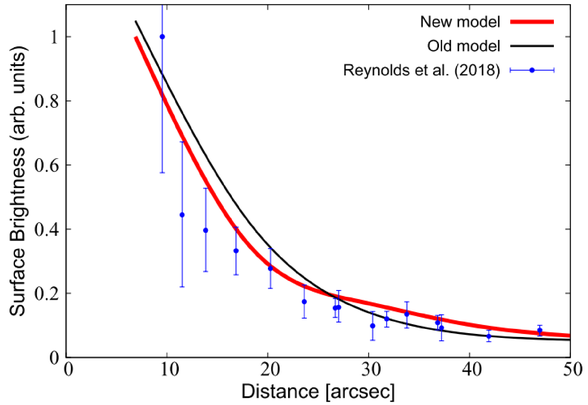

Figure 2. X-ray surface brightness (SB) for Kes 75 for old (in black) and new (in red) model with respect to distance from the centre of the PWN (in arcsec). The measured profile from [2] is shown as blue data points.

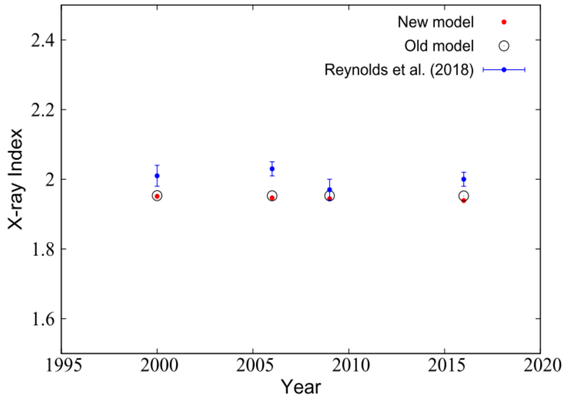

Figure 3. Predicted X-ray photon indices for Kes 75 shown for old (in black) and new (in red) model, spanning from 2000 to 2016. Inferred values by [2] for the corresponding years are also shown in blue.

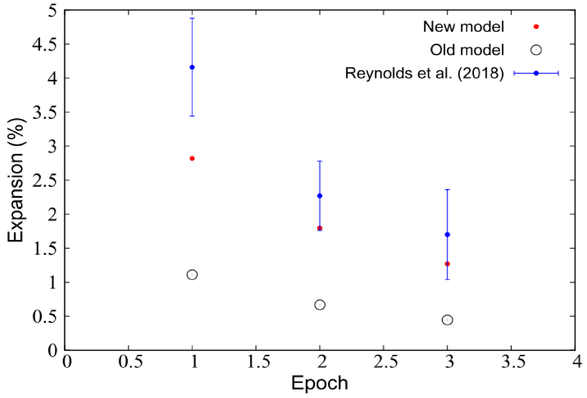

Figure 4. Expansion of Kes 75 for three different epochs (1: 2000-2016, 2: 2006-2016 and 3: 2009-2016), for old (in black) and new (in red) model. Values fitted by [2] for the corresponding epochs are shown in blue.

DISCUSSION

- We presented improved fits to all four features (SED, SB profile, spectral index vs. r, and expansion,) using our new model.
- Work in progress to refine the parameters to obtain an even better fit to Kes 75 (Van Rensburg et al., in preparation).
- Our future aim is to study the effect of different changes to the underlying physics, and to fine-tune the code for a sample of PWNe.

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