PSR B0656+14: Combined Optical, X-ray & EUV Studies

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Abstract.

PSR B0656+14’s high energy emission is consistent with that of combined magnetospheric and thermal (surface & polar cap) emission. Uncertainties with the radio-derived distance and X-ray instrumentation sensitivities complicate a definitive thermal characterisation however. A re-analysis of combined ROSAT/EUVE archival data in conjunction with integrated & phase-resolved optical photometry is shown to constrain this characterisation.

1. Introduction

Considerable uncertainty remains regarding the fundamental thermal parameters ($T, N_H, R/d$) for PSR B0656+14. Radio derived DM estimates (790 ± 190 pc) disagree with the best $N_H$ model fits (250 - 550 pc). Reported calibration uncertainties associated with the low energy channels of the ROSAT PSPC complicate the latter - although agreement between other ROSAT PSPC & observed EUVE fluxes obtained via a correction (e.g. for RX J185635-3754, Walter & An, 1998). We outline the results of such a correction to the existing PSPC datasets archived for PSR B0656+14 via substitution of the low energy channels with measured EUVE fluxes, and by incorporating independently derived constraints to the Rayleigh-Jeans tail in the optical, discuss the implications for the neutron star’s thermal parameters.

2. Technical & Analytical Overview

Optimum thermal fits for $T_{soft}, T_{hard}, N_H, R/d$ were obtained for the archived ROSAT PSPC data alone and the PSPC data with the suspect low energy channels substituted with the archival normalised EUVE flux. This substitution results in a significant change in solution space, as shown in Figure 1 (Edelstein et al. 1999). Based on integrated optical photometry, Pavlov et al. (1997) fitted a two component nonthermal/thermal model, the thermal fit defined by a parameter $G = T_{soft}K(R_{10km}/d_{500pc})^2$ where $G = [1 - 7]$ (see Figure 1). A $1\sigma$ upper limit on the unpulsed component from the optical $B$ band light curve
of Shearer et al. (1997) limits $G \leq 4.4, 4.8$ and $5.2$, based on various optical extinction models to the pulsar (Golden, 1999). These optical results yields tighter constraints on parameter space, as can be seen.

3. Discussion & Conclusions

Combining the EUVE & ROSAT datasets in this way yields new solutions in parameter space that are further constrained independently via recent optical work. Assuming a simple blackbody form then $T_{\text{surface}} \geq 5.0 \times 10^5$ K and for the $N_H$-derived distances of $[250 - 280]$ pc, $R_{\odot} \leq [17.7 - 14.7]$ km. Using the estimate of $R_{\odot} \sim 9.5^{+3.3}_{-2.0}$ km for Geminga as a working upper limit (Golden & Shearer, 1999) places PSR B0656+14 at a distance of no less than $d = 152^{+55}_{-32}$. This suggests the possibility of parallax observations to independently derive $d$, with immediate implications for the $R$ parameter, and consequently models of the condensed matter equation of state.

References

Golden, A., 1999, Ph.D. Thesis, National University of Ireland, Galway
Walter, F.M., & An, P. 1998, AAS, 192, 82.07