DISCOVERY OF AN OB RUNAWAY STAR INSIDE SNR S147

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Introduction

- Searching OB Runaway Stars Inside SNRs
  - Candidate Selection via BVJHK Colors
  - SpT Confirmation & RV Determination
- Calar Alto Observatory: CAFOS on 2.2 meter Telescope
- TUBITAK National Observatory: TFOSC on RTT-150
- University Observatory of Jena: FLECHAS on 90 cm Schmidt Telescope
- In 2013, 59 Observed; 26 B-type Stars Found
- 15 Prominent OB Stars inside 9 SNRs
HD 37424 in SNR S147
HD 37424 in SNR S147

- $V = 9.0$ mag, $RA = 05:39:44.4$ Dec = $+27:46:51.2$
- Ang. Separation from G.C = ~10 arcmin
- High PM; pmRA = $10.8 \pm 0.8$, pmDec = $-10.2 \pm 0.6$
- SpT = B0.3V $\pm 0.3$ (Dincel+ 2014 in prep)
- SpT = B0.5/1V (Skiff+, 2009)
- MK-Distance = $1265 \pm 125$ pc
- TFOSC Spectra R$\sim$1300
- HeII $\lambda 4200$
- HeI, OII, SiIII/IV are indicators
HD 37424 (High-Res)

- TRES Observations (September, 2013)
- Fred L. Whipple Telescope 1.5 m (SAO, Arizona)
- $R \sim 30000 - 60000$, ExpTime = 300 sec
- RV of Star & ISM lines; CaII-H/K, NaI-D1/D2
- Distance from CaII-H/K Lines
HD 37424 (Measurements)

- 10 Lines Used for RV
- RV =  -9.2 ± 6.5 km/s,  -9.1 ± 5.5 km/s
- CaII-K = 12.5 km/s
- CaII-H = 11.7 km/s
- NaI-D1 = 11.9 km/s
- NaI-D2 = 11.7 km/s
- Distance (Ca-K/H) = 1355 pc
- U_err = 133 pc, L_err = 121 pc
SNR S147

- Shell Type SNR
- Optical Filaments
- Gal.Coord: 180.0-1.7
- Diam. = 180 arcmin
- Distance = 0.8-1.8 kpc
- NS: PSR J0538+2817
- Radio, Optical, Gamma
- No X-ray

Hα Image of SNR S147 (Uni. Observatory of Jena)
PSR J0538+2817

- $D = 1.3 \pm 0.22 / -0.16$ kpc from Plx (Chatterjee+, 2009)
- $P = 143$ ms, $P_{\text{dev}} = 3.6694515 \times 10^{-15}$, $\tau = 618$ kyr
- Kin. Age = 30 kyr (PSR-SNR Relation) (Kramer+, 2003)
- High Spin Period at Birth? $P_0 = 130$ ms
- $\text{pm}(\text{RA}) = -23.57 \pm 0.1$, $\text{pm}(\text{Dec}) = 52.87 \pm 0.1$
- At 1.3 kpc; $V_{\text{trans}} = 383 \pm 1$ km/s
- PWN in X-ray
Kinematics

- HD 37424 - PSR Relation based on 3-D Monte Carlo Simulation
- 3-D Vel. Trace Back Coincidence; 30 ± 4 kyr.
- At RA = 84.82 +/- 0.01, Dec = +27.84 ± 0.01
- HD 37424 $V_{\text{pec}}$ = 74 ± 7.5 km/s
- HD 37424 ~15 M$_{\text{sun}}$
- Pre-SN Binary
Kinematics (Spin-Kick Align.)

- Binary Rest Frame
- Spin-Kick Alignment
- PA(space) = -23.1 ± 0.1 deg
- PA(spin) = -11 ± 4 deg  
  (Ng & Romani, 2007)
- For 15 M_{sun} Companion
- PA(kick) = -15.7 ± 1.1 deg
Results & Conclusion

- Discovery of Runaway – PSR Pair with High Accuracy
- High Mass Progenitor (>15 $M_{\text{sun}}$) for PSR 0538+2718
- Precise SNR Distance: 1333 ± 112 pc
- SNR Age: 30 ± 4 kyr
- A Step for PSR – Progenitor Binary Evolution Relation
- Further Observations for SN Debris
THANK YOU