Search for Runaway Stars in the SNR G184.6-5.8

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Motivation

Half of all stars and in particular 70 % of the massive stars are part of a multiple system. A possible development for the system after the core collapse supernova (SN) of the more massive component is as follows: The binary is disrupted by the SN.
The formed neutron star is ejected by the SN kick whereas the companion star either remains within the system and is gravitationally bounded to the neutron star, or is ejected with a spatial velocity comparable to its former orbital velocity (up to 500 km/s).
Such stars with a large peculiar space velocity are called runaway stars.

Two possible scenarios for runaway stars:

- Ejection via gravitational interactions between the stars in clusters,
- Binary disruption as a result of a SN. Both move away from the geometrical center of the SNR.[1]

We deal with the second scenario. A recent discovery in our working group of an OB runaway star inside SNR S 147 is presented at this conference[2] (Dinçel).
In the given project we focus not only on OB runaways but also on low mass stars. Here we discuss our initial observational results on the SNRs G184.6-5.8.

SNR G184.6-5.8

SNR

- Distance: 2 kpc (via μ and RV); 2.5 kpc (DM)
- Size: 7 x 5 arcmin

PSR B0531+21

- Period: 0.033 s
- $\mu_\alpha^* = -14.7 \pm 0.8$ mas yr^{-1}
  $\mu_\delta = 2.0 \pm 0.8$ mas yr^{-1}
- $\tau = 1.26$ kyr

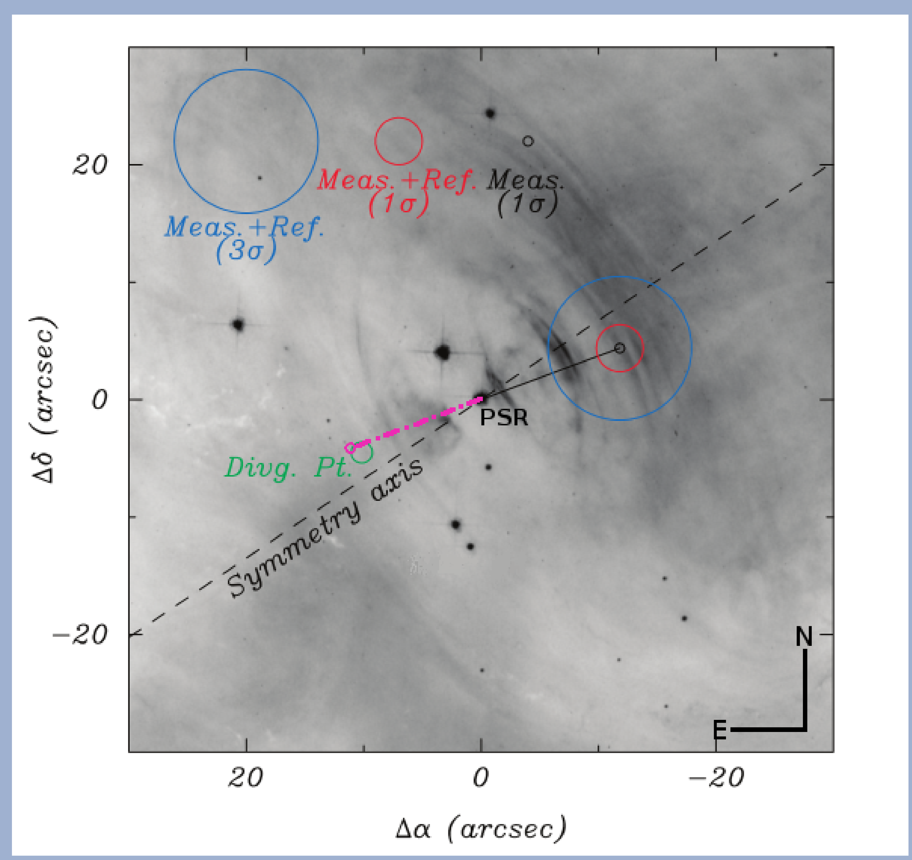

Fig.1: Proper motion of the Crab PSR. Magenta line: projection of the proper motion back to 1054 AD, green circle: divergent point with ± 1 σ uncertainties. Black vector: proper motion 1000 years from now with different uncertainties (image from[3]).

Observations

Selection

- Stars within 1 arcmin from the PSR position in 1054 AD
- V magnitudes up to 17 mag

Observations

- Calar Alto 2.2 m, CAFOS spectra on Jan 2016, λ 3200-7000Å, R∼550
- Tautenburg 2 m Nasmyth spectra on Nov 2014, λ 2300-9000Å, R∼900

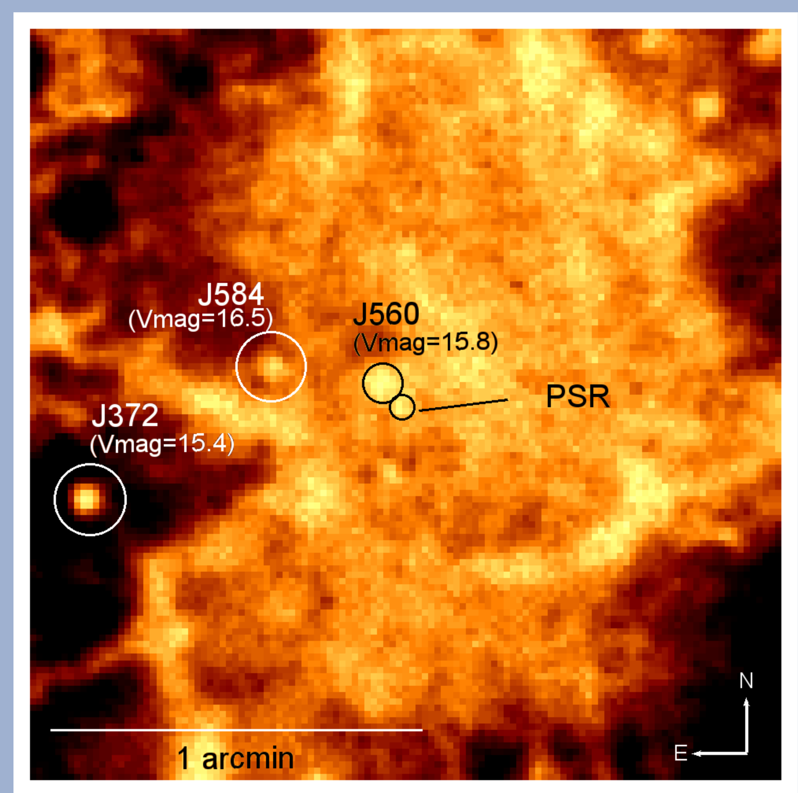

Fig.2: Observed targets of G184.6-5.8. The angular distances from the center of explosion correspond to 9.7" (J560), 14.6" (J584) and 42" (J372) respectively. This correlates to expected runaway velocities of 120kms^{-1}, 180kms^{-1} and 520kms^{-1} which are consistent with the established runaway values[4].

Analysis

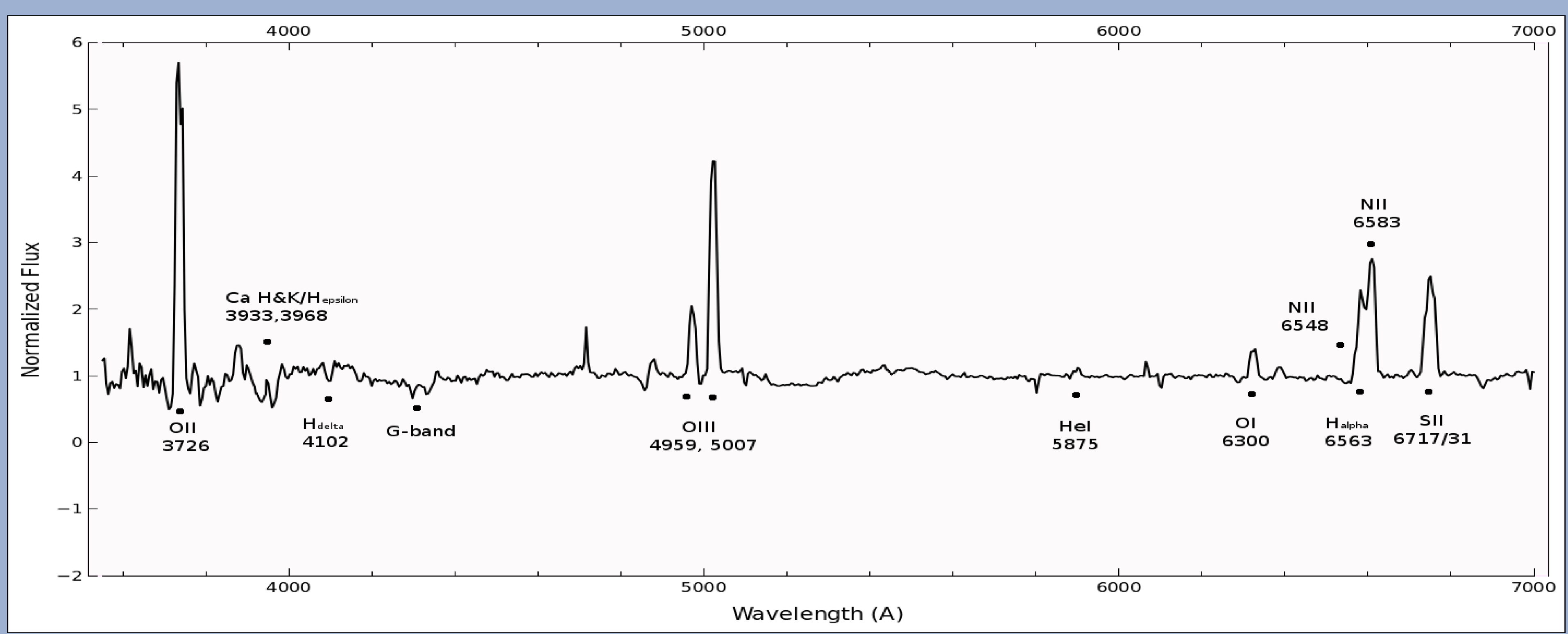

Fig.3: CAFOS spectrum of J560, indicated emission lines originate from the SNR. The absorption lines are Ca H&K interstellar lines with stellar H λ3970 blend.

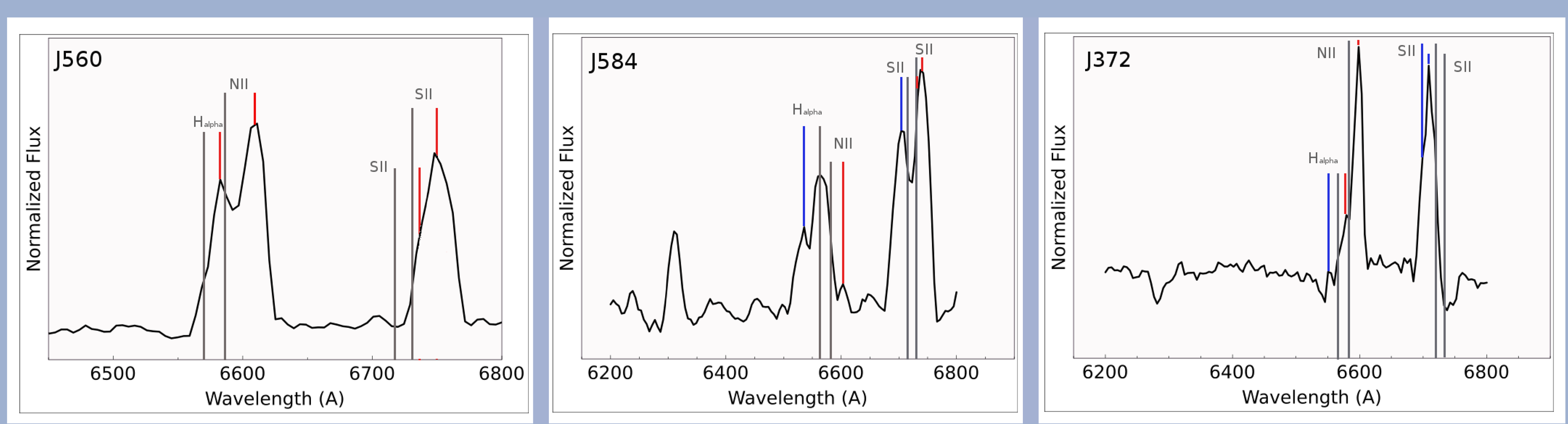

Fig.4: *a)* Red shifted Hα (λ6581, +18Å), NII (λ6609, +26Å) and SII (λ6735, +18Å and λ6750, +19Å) lines of J560. *b)* and *c)* Blue and red shifted H and SII lines in J584 and J372 respectively. The SNR gas velocity amounts to ∼ 1000kms^{-1} which is consistent with the known values from e.g. Cadez et al., 2004ApJ...609..797C.

Targets

Target	U	B	V	R	I	J	H	K
J584	17.8	17.49	16.51	15.92	15.36	14.62	14.26	14.2
J560	16.8	16.64	15.79	15.25	14.74	14.06	13.71	13.54
J372	16.56	16.29	15.37	14.78	14.22	13.45	13.04	12.92

Tab.1: Magnitudes of the targets (2009AA...504..525S, 2003yCat.2246....0C).

Target	sp.type
J584	K0 to K5
J560	G7 to K0
J372	K0 to K5

Tab.2: Estimated spectral types of the targets.

Target	M(V) III	M(V)V	dist III (pc)	dist V (pc)
J584	0.58 to -0.8	5.32 to 7.24	6109 to 11 535	688 to 284
J560	0.4 to 0.58	4.83 to 5.32	4764 to 4385	619 to 494
J372	0.58 to -0.8	5.32 to 7.24	3614 to 6823	407 to 168

Tab.3: Absolute magnitudes M and calculated MK distances for luminosity class III and V[5] with the assumed extinction A_V=2 mag.

Results

Background stars

The observed targets are all of a late G or early K type (cf. G-band, weak H lines and color indices) and are located behind the Crab SNR (cf. red and blue shifted lines of the SNR ejecta). No other objects are situated within the 1 arcmin radius around the PSR and V_{mag} <17.
This has now two conclusions: firstly all of the targets can be of LC III and thus situated more than 2.5 kpc away from the Solar system. Secondly, if the targets are dwarfs then the distance to the Crab SNR has to be reduced to a few hundred pc. A careful determination of their luminosity class (on spectra with a greater resolution) will solve this problem.

Runaway

The putative runaway has to be fainter than V_{mag}16.5 apparent magnitudes. At the assumed distance of 2.5 kpc this will lead to an absolute magnitude of M$_V$∼4.5 mag[5] which corresponds to a G5V or later type stars.
Due to the mass of 9.5 M$_{Sun}$[6] of the SNR progenitor star the SN event occured after some ∼Myr.
So any of the G dwarfs could reach the ZAMS within this time and should still be more luminous PMS objects.

References

[1] Blaauw 1961, BAIN, 15, 265
[2] Dincel et al. 2015, 2015MNRAS.448.3196D
[3] Ng et al. 2006, 2006ApJ...644..445N
[4] Tetzlaff et al. 2010, MNRAS, 402, 2369-2387
[5] Wegner 2006, MNRAS, 374, 1549-1556
[6] MacAlpine et al. 2008, 2008AJ....136.2152M