Runaway-Sterne, Neutronensterne und (nahe) Supernovae

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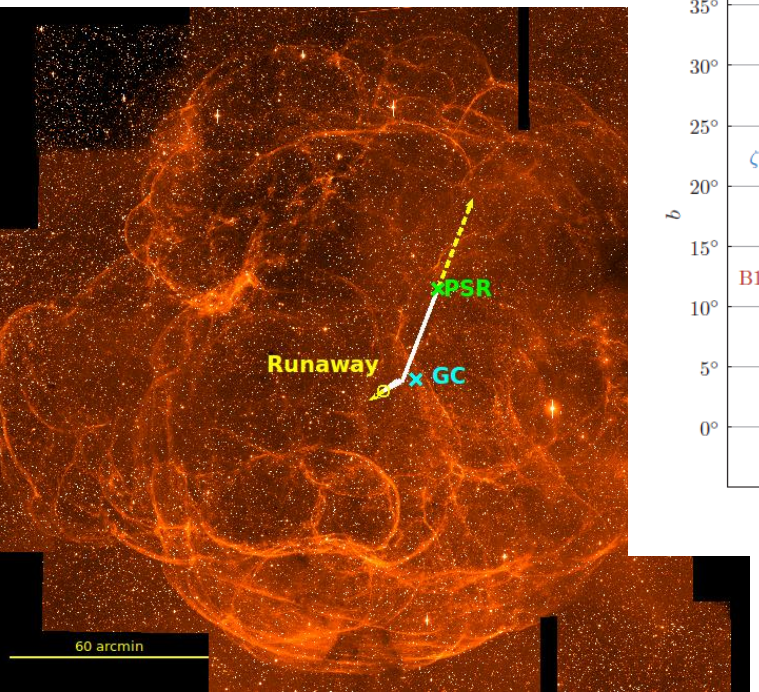
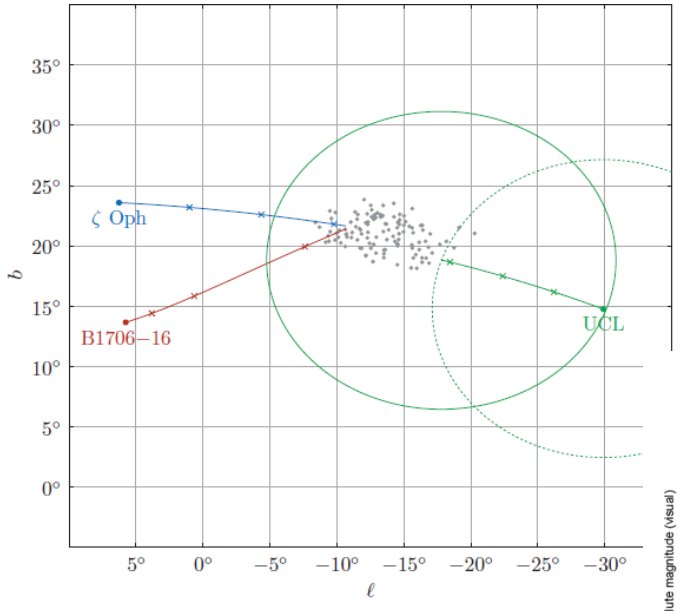
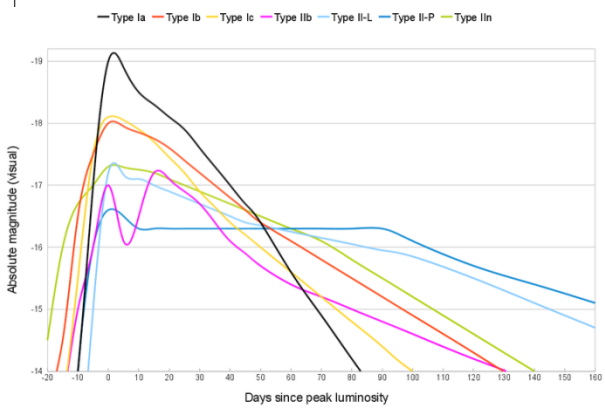






Runaway-Sterne: Ungewöhnlich hohe 3D-Raumgeschwindigkeit

• Begleiter von Sternen, die als Supernova explodieren (Binary Supernova Scenario, Blaauw 1961)
or
• aus Sternhaufen herausgeschleudert (Dynamical Ejection Scenario, Poveda et al. 1967)

➢ 2 Populationen (Stone 1979):
  • normale Population I Sterne (wenige km/s)

  • Runaway-Sterne: schneller

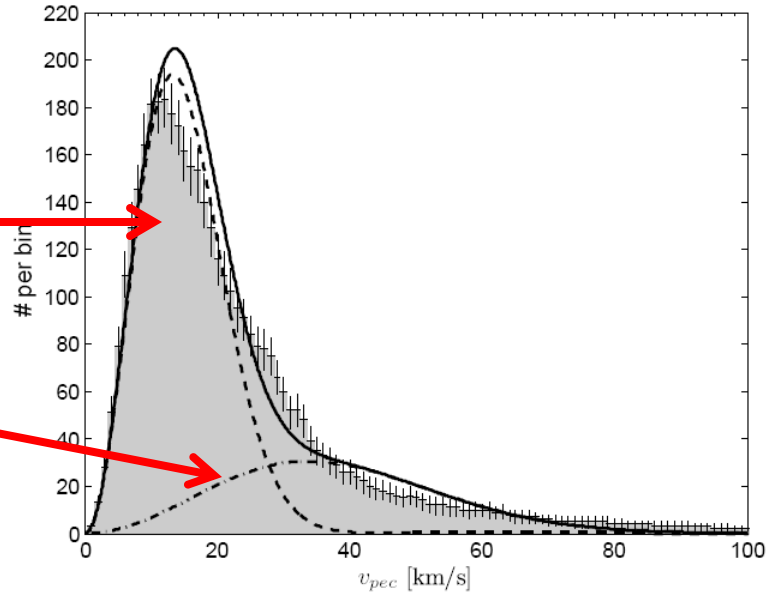
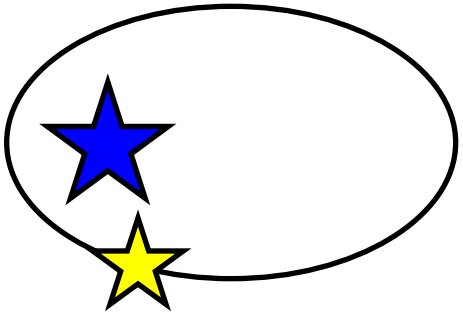
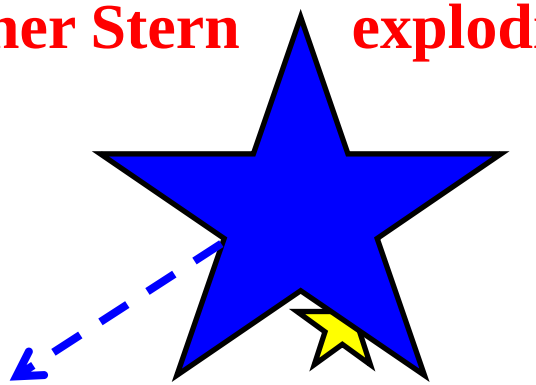


Figure 1. Distribution of the peculiar space velocity v_{pec}. The dashed curve shows the distribution for the low velocity group whereas the dashed-dotted curve is for the high velocity group. The two curves intersect at $v_{pec} = 28\,\mathrm{km/s}$. The total distribution as the sum of the two is represented by the full line.

Supernova im Doppelstern:

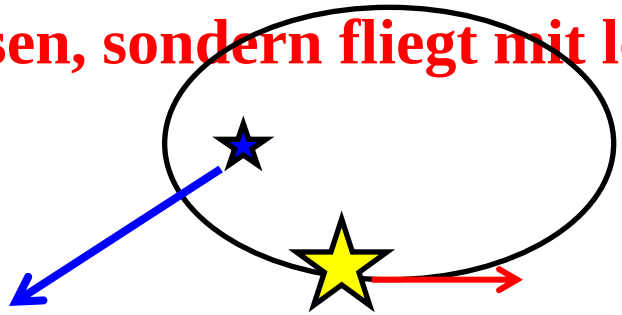


(1) Massereicher Stern explodiert (zuerst) als Supernova



(2) Neutronenstern entsteht und fliegt weg
(SN assymetrisch, Neutrino-Kick)

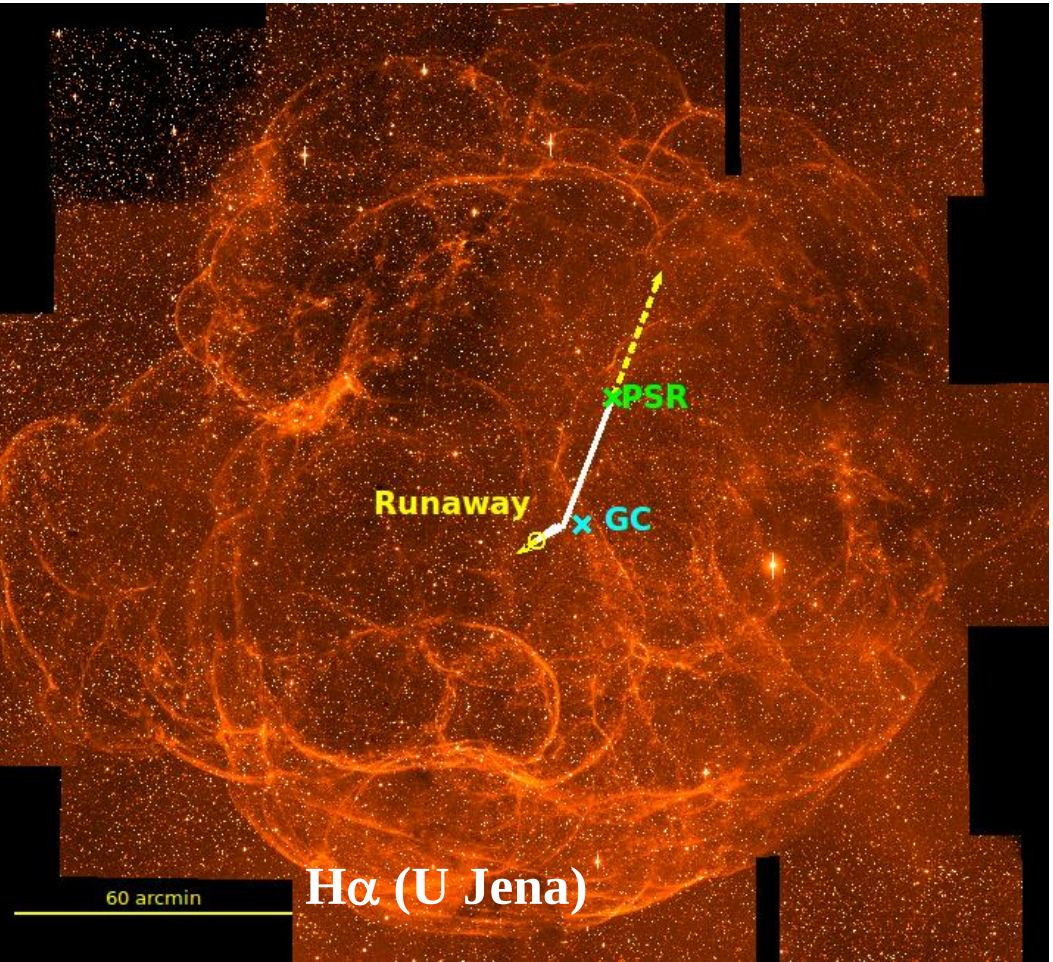
(3) Vorheriger Begleiter hat Zentralstern verloren, kann ihn nicht mehr umkreisen, sondern fliegt mit letzter Orbit-Geschw. geradeaus weiter.

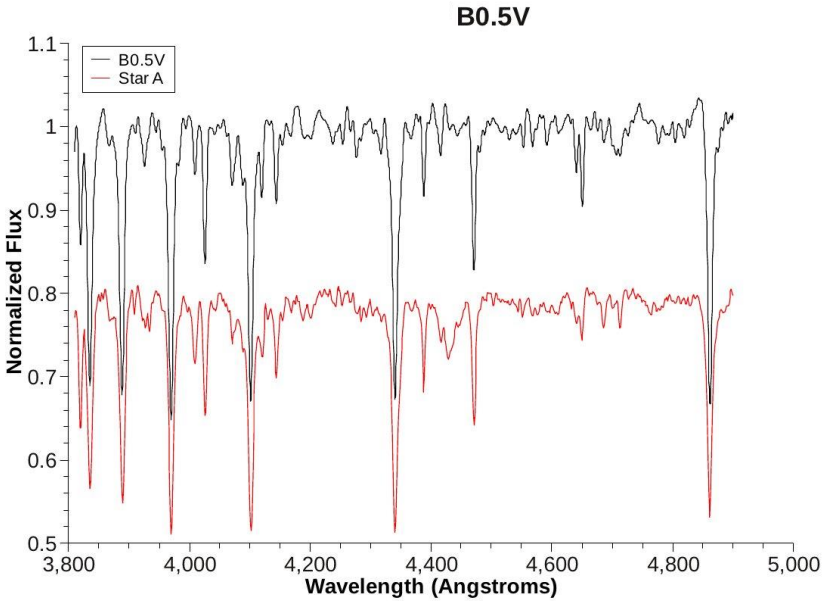


Runaway-Stern und Pulsar im Supernova-Überrest S 147:

Pulsar und B0.5-type Stern gleichzeitig nahe dem geometrischen Zentrum des SN-Überrestes, Supernova vor ca. 30.000 Jahren

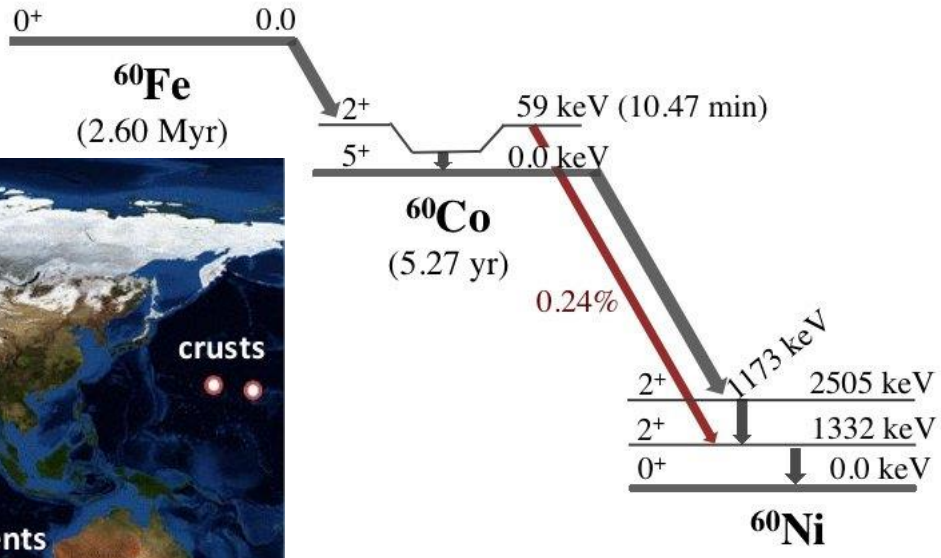
➔ Bestätigt SN-Szenario für Runaway-Sterne

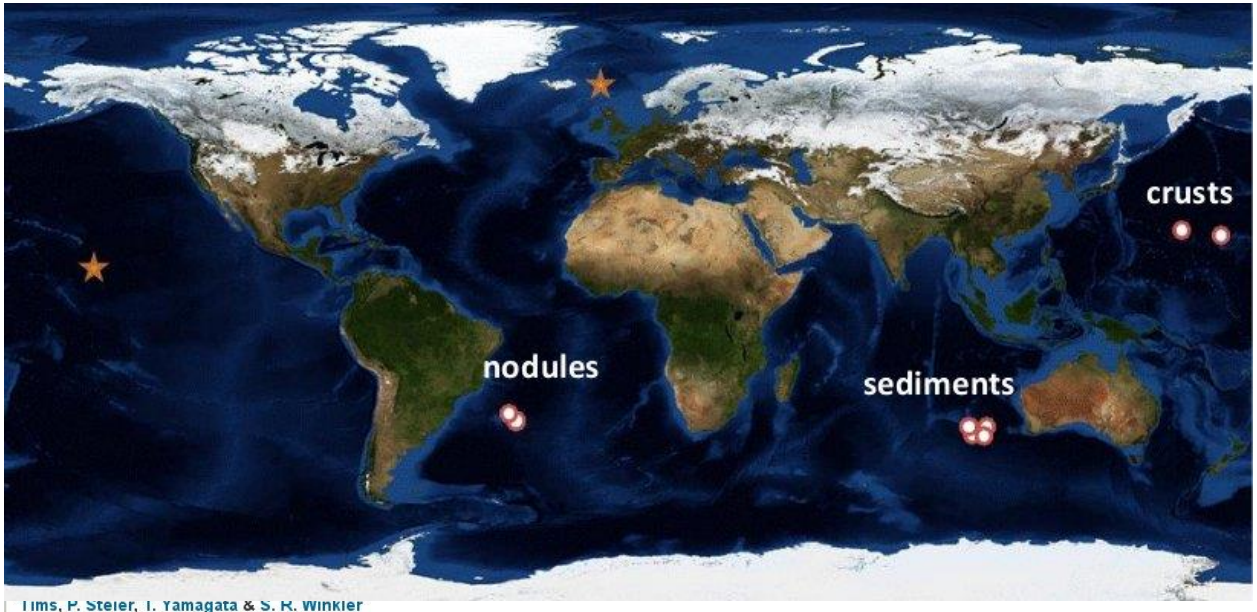




Dincel, Neuhäuser et al. 2015, MNRAS

^{60}Fe in der Erdkruste: von Supernovae





Tims, P. Steier, T. Yamagata & S. R. Winkler
Nature **532**, 69–72 (07 April 2016) | doi:10.1038/nature17196

Knie et al.1999 PRL … Wallner et al. 2016 Nature

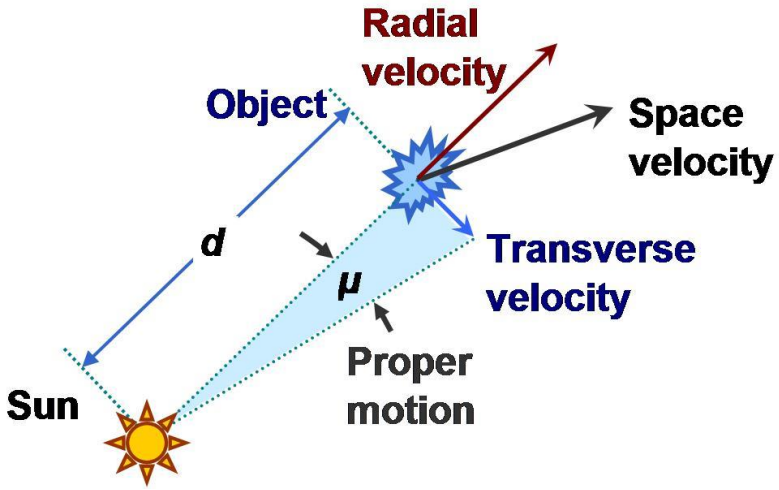
Table 3: Summary of ^{60}Fe deposition at various locations

Deep-sea archive	Cores	Location	Time period (Myr)	^{60}Fe detector events	^{60}Fe deposition (10^6 atoms cm^{-2})
Sediment	4	Indian Ocean	1.71–3.18	288	35.4 ± 2.6
FeMn Crust-1	2	Pacific Ocean	0–4.35	97	5.9 ± 0.8
FeMn Crust-1			6.52–8.70	26	3.5 ± 1.4
FeMn Crust-2			1.2–3.1	94	2.2 ± 0.2
FeMn nodules	2	Atlantic Ocean	1.8–3.3	13	0.6 ± 0.2
			0–3.3	20	1.4 ± 0.5
FeMn Mona Pihoa[10]	1	Pacific Ocean	0–5.9	21	~ 9^{+11}_{-6} ‡
FeMn 237KD[11]	1	Pacific Ocean	1.74–2.61*	69	1.5 ± 0.4*
Lunar material[22]	4	Moon	Integral	†	~10

Data were obtained in this work and as given in the literature[10, 11, 22] (no correction for incorporation efficiency). Uncertainties are 1σ. For Crust-1 and Crust-2 an incorporation efficiency of 17% and 7%, respectively, has to be taken into account to calculate the ^{60}Fe fluence from the deposition values; similarly 2% and 4% for the nodules.

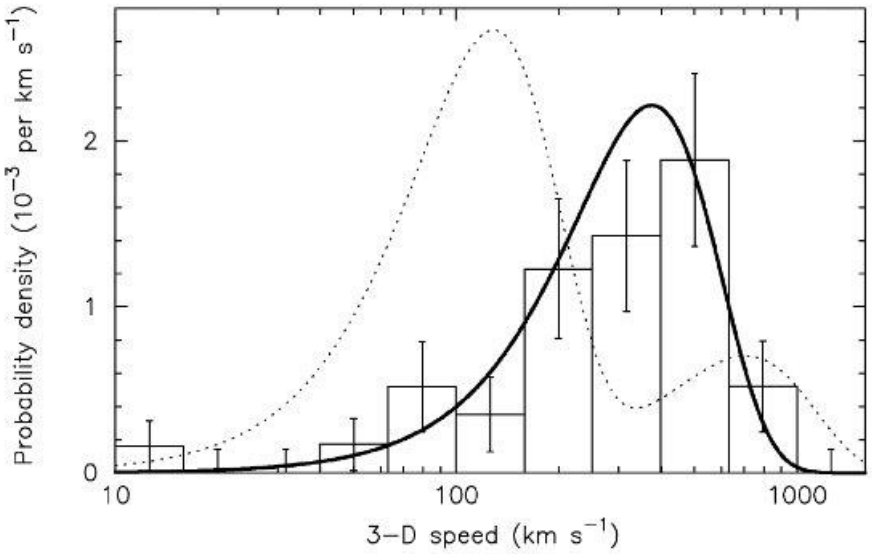
^{60}Fe in Erdkruste, antarktischem Schnee und auf dem Mond.

Input:



~ 600 Runaway-Sterne: (6D)

Position, Parallaxe,
Eigenbewegung (2D), und
Radial-Geschw. (1D) bekannt

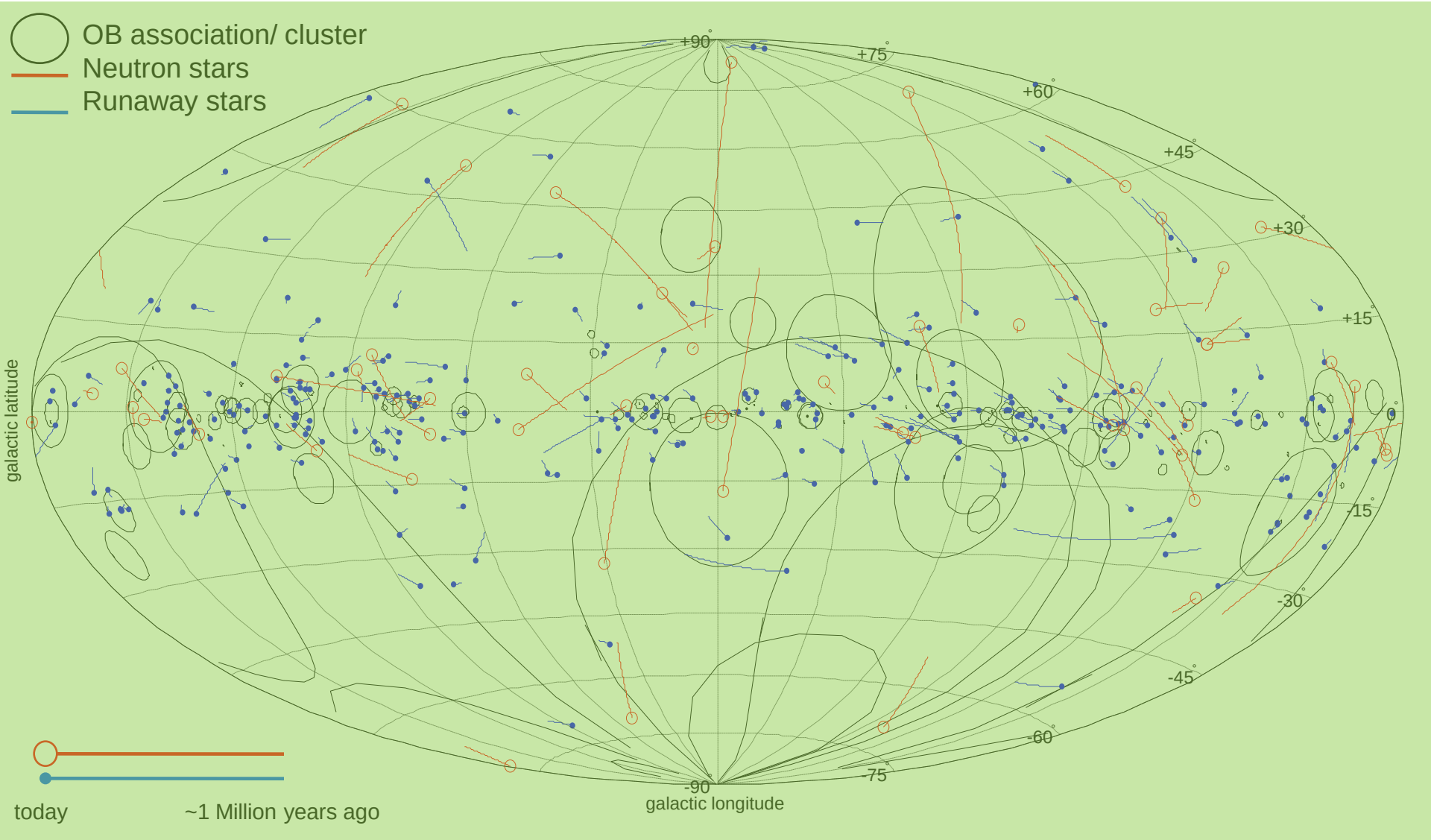


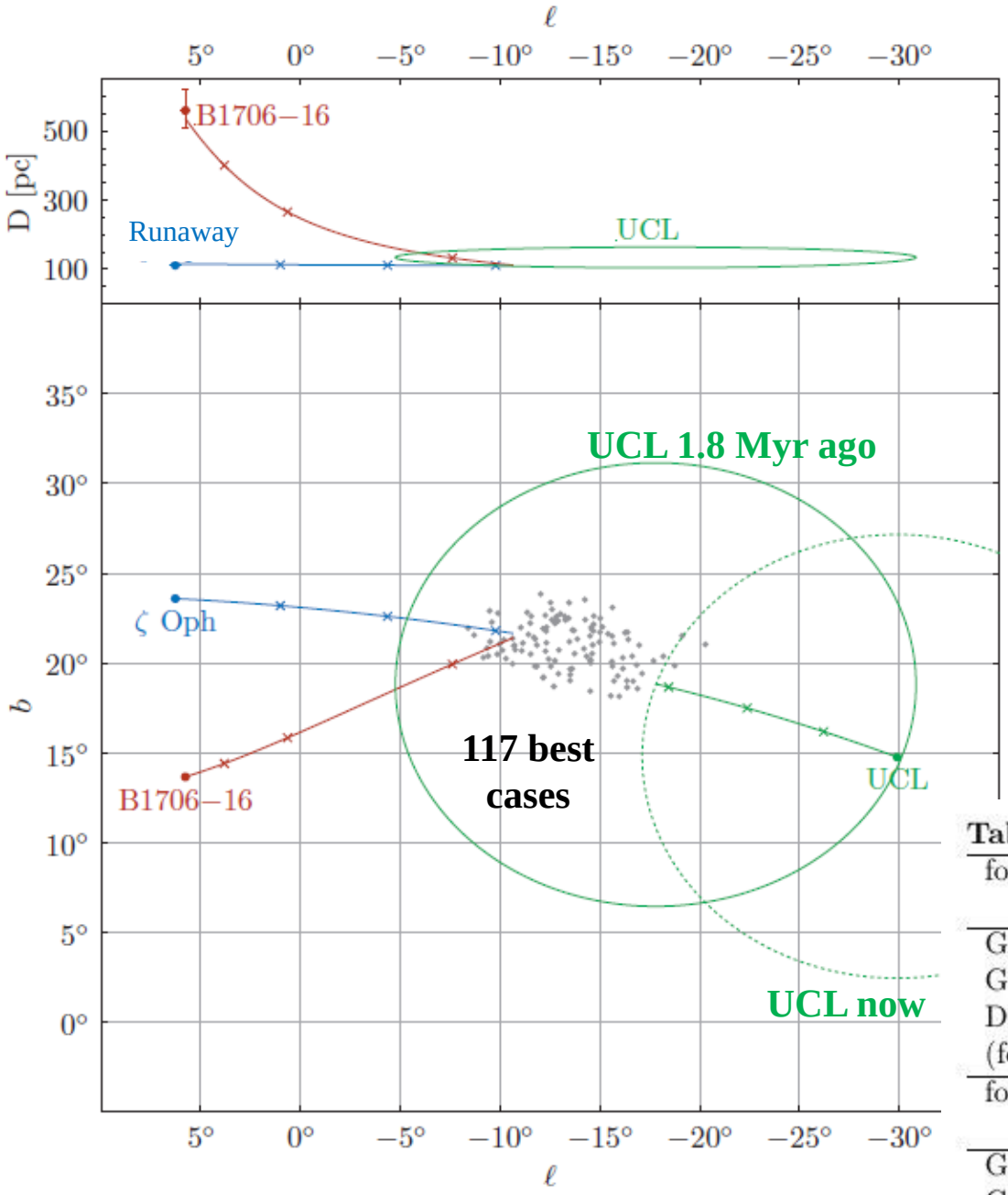
~ 400 Neutronensterne: bis zu ca. 50 Mio J., bis zu einigen kpc

Position, Parallaxe, Eigenbewegung bekannt (5D)

Radial-Geschw. meist unbekannt -
RV aus wahrsch. 3D-Verteilung
(Maxwellian with rms 265 km/s),
dann Monte-Carlo Simulation

Runaway-Sterne und Neutronensterne durch das galaktische Potential zurückverfolgen, um Supernovae in Doppelsternen zu finden





Neuhäuser, Gießler, Hambaryan, 2020, MNRAS

Bisher ein Paar gefunden:

Runaway-Stern ζ Oph

+

Neutronenstern PSR B1706

Vor ~1.8 Mio J. in UCL

Zur selben Zeit

am selben Ort

innerhalb 0.5 pc in UCL

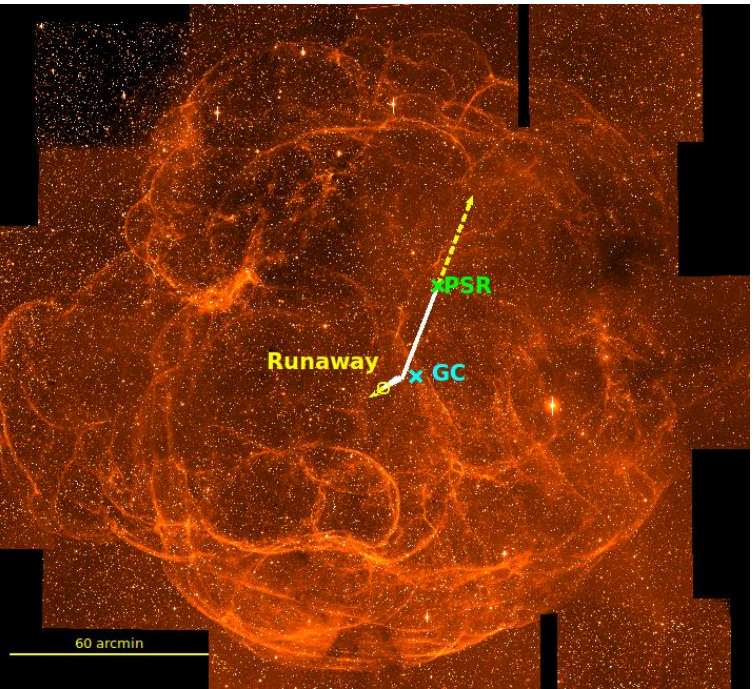
(SN im Binary ~110 pc)

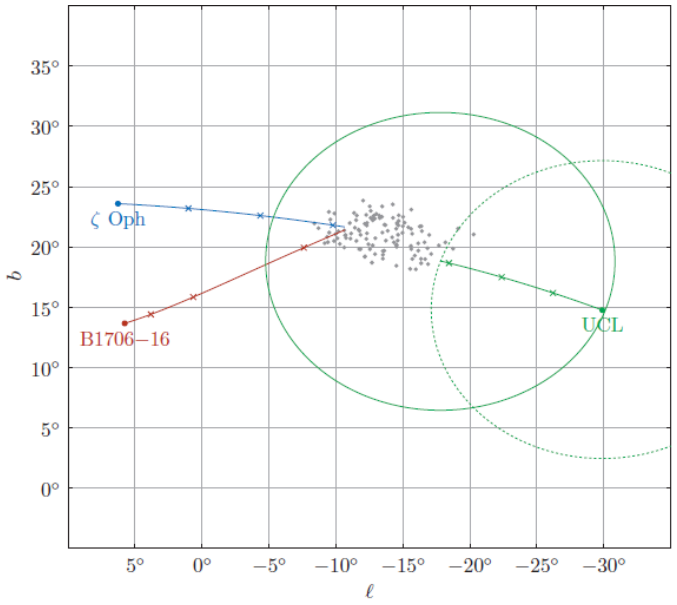
Table 1: Predicted Supernova position:

for best case approach within 0.5 pc inside UCL:		
	1.58 Myr ago	present day
Galactic longitude l	−10.7°	−18.9°
Galactic latitude b	21.55°	13.4°
Distance from Earth	111.2 pc	107.9 pc
(for pulsar radial velocity 265.5 km/s)		
for 117 best case approaches within 10 pc inside UCL:		
	1.78 ± 0.21 Myr ago	present day
Galactic longitude l	−13 ± 3°	−16 ± 4°
Galactic latitude b	21 ± 2°	15 ± 3°
Distance from Earth	107 ± 4 pc	109 ± 5 pc
(for pulsar radial velocity 260 ± 43 km/s)		

Mögliche Bachelorarbeiten:

(1) Vergleich verschiedener Entfernungsbestimmungs-Methoden bei Neutronensternen
(2) Alter von Supernova-Überresten mit Neutronensternen darin bestimmen
(3) Entfernung von Supernova-Überresten bestimmen
(4) Lichtkurven von verschiedenen Supernova-Typen





Mögliche Bachelorarbeiten:

Vergleich verschiedener Entfernungsbestimmungs-Methoden bei Neutronensternen

ATNF Pulsar Catalogue

Catalogue Version: 2.5.1

#	NAME		PMRA (mas/yr)			PMDEC (mas/yr)			P0 (s)			P1			DIST (kpc)	DIST_DM (kpc)		DM*sin(b) (cm^-3 pc)	ASSOC
1	J0002+6216	cwp+17	32.5	6	bst+23	-13.7	6	bst+23	0.1153635682680	14	cwp+17	5.96703E-15	7	cwp+17	6.357	6.357	ymw17	-0.28	GRS:4FGL_J0002.8+
2	J0006+1834	cnt96	*	0	*	*	0	*	0.693748	0	dmo+24	2.097E-15	12	cn95	0.860	0.860	ymw17	-7.78	*
3	J0007+7303	aaa+09c	*	0	*	*	0	*	0.3158731909	3	awd+12	3.6039E-13	5	awd+12	1.400	*	*	*	GRS:4FGL_J0007.0+
4	J0011+08	dsm+16	*	0	*	*	0	*	2.55287	0	dsm+16	*	0	*	5.399	5.399	ymw17	-19.99	*
5	J0012+5431	dcm+23	*	0	*	*	0	*	3.02530070997	19	dcm+23	1.28e-16	0	dcm+23	5.427	5.427	ymw17	-18.07	*
6	B0011+47	dth78	19.3	18	bfg+03	-19.7	15	bfg+03	1.240699038946	11	hlk+04	5.6446E-16	14	hlk+04	1.776	1.776	ymw17	-7.68	*
7	J0021-0909	clh+20	*	0	*	*	0	*	2.31413082909	17	clh+20	1.039E-15	17	clh+20	25.000	25.000	ymw17	-23.79	*
8	J0023+0923	hrm+11	-11.00	7	bbc+24	-8.80	10	bbc+24	0.003050203104754390	4	aab+21a	1.142345E-20	14	aab+21a	1.818	1.248	ymw17	-11.42	GRS:4FGL_J0023.4
9	B0021-72C	mld+90	5.25	3	vb21	-2.55	3	vb21	0.00575677999551635	14	frk+17	-4.98503E-20	20	frk+17	4.520	2.593	ymw17	-17.36	GC:47Tuc(NGC104),J
10	B0021-72D	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.00535757328486573	9	frk+17	-3.4220E-21	9	frk+17	4.520	2.630	ymw17	-17.46	GC:47Tuc(NGC104),J
11	B0021-72E	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.00353632915276244	4	frk+17	9.85103E-20	6	frk+17	4.520	2.510	ymw17	-17.10	GC:47Tuc(NGC104),J
12	B0021-72F	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.00262357935251262	4	frk+17	6.45029E-20	7	frk+17	4.520	2.544	ymw17	-17.21	GC:47Tuc(NGC104),J
13	B0021-72G	rlm+95	5.25	3	vb21	-2.55	3	vb21	0.00404037914356515	14	frk+17	-4.21584E-20	17	frk+17	4.520	2.556	ymw17	-17.25	GC:47Tuc(NGC104),J
14	B0021-72H	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.00321034070935032	11	frk+17	-1.8294E-21	11	frk+17	4.520	2.543	ymw17	-17.21	GC:47Tuc(NGC104),J
15	B0021-72I	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.00348499206166289	13	frk+17	-4.5874E-20	3	frk+17	4.520	2.555	ymw17	-17.24	GC:47Tuc(NGC104),J
16	B0021-72J	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.00210063354535246	5	frk+17	-9.7917E-21	9	frk+17	4.520	2.594	ymw17	-17.36	GC:47Tuc(NGC104),J
17	B0021-72L	rlm+95	5.25	3	vb21	-2.55	3	vb21	0.0043461679994616	4	frk+17	-1.22045E-19	4	frk+17	4.520	2.547	ymw17	-17.22	GC:47Tuc(NGC104),J
18	B0021-72M	mlr+91	5.25	3	vb21	-2.55	3	vb21	0.0036766432176002	3	frk+17	-3.8419E-20	6	frk+17	4.520	2.552	ymw17	-17.23	GC:47Tuc(NGC104),J
19	B0021-72N	rlm+95	5.25	3	vb21	-2.55	3	vb21	0.00305395434626085	10	frk+17	-2.18570E-20	19	frk+17	4.520	2.585	ymw17	-17.33	GC:47Tuc(NGC104),J
20	J0024-7204O	clf+00	5.25	3	vb21	-2.55	3	vb21	0.00264334329724357	5	frk+17	3.03493E-20	6	frk+17	4.520	2.537	ymw17	-17.19	GC:47Tuc(NGC104),J
21	J0024-7204P	clf+00	5.25	3	vb21	-2.55	3	vb21	0.0036430207	3	rft+16	6.6E-19	40	rft+16	4.520	2.523	ymw17	-17.15	GC:47Tuc(NGC104)
22	J0024-7204Q	clf+00	5.25	3	vb21	-2.55	3	vb21	0.00403318118457258	15	frk+17	3.4008E-20	4	frk+17	4.520	2.520	ymw17	-17.14	GC:47Tuc(NGC104),J
23	J0024-7204R	clf+00	5.25	3	vb21	-2.55	3	vb21	0.00348046270749329	13	frk+17	1.48352E-19	3	frk+17	4.520	2.538	ymw17	-17.19	GC:47Tuc(NGC104),J
24	J0024-7204S	clf+00	5.25	3	vb21	-2.55	3	vb21	0.00283040595787912	8	frk+17	-1.205413E-19	9	frk+17	4.520	2.543	ymw17	-17.21	GC:47Tuc(NGC104),J
25	J0024-7204T	clf+00	5.25	3	vb21	-2.55	3	vb21	0.0075884798073671	12	frk+17	2.93805E-19	12	frk+17	4.520	2.553	ymw17	-17.24	GC:47Tuc(NGC104),J
26	J0024-7204U	clf+00	5.25	3	vb21	-2.55	3	vb21	0.00434282669639233	12	frk+17	9.52279E-20	17	frk+17	4.520	2.535	ymw17	-17.18	GC:47Tuc(NGC104),J
27	J0024-7204V	clf+00	5.25	3	vb21	-2.55	3	vb21	0.00481016762	7	rft+16	*	0	*	4.520	2.480	ymw17	-17.01	GC:47Tuc(NGC104)

Mögliche Bachelorarbeiten:

Alter von Supernova-Überresten *mit* Neutronensternen darin bestimmen

ATNF Pulsar Catalogue

Catalogue Version: 2.5.1

Alter < P_0 / P_1

#	NAME		PMRA (mas/yr)			PMDEC (mas/yr)			P0 (s)	P1	DIST (kpc)	DIST_DM (kpc)	DM*sin(b) (cm^-3 pc)	ASSOC
1	J0002+6216	cwp+17	32.5	6	bst+23	-13.7	6	bst+23						
2	J0006+1834	cnt96	*	0	*	*	0	*						
3	J0007+7303	aaa+09c	*	0	*	*	0	*						
4	J0011+08	dsm+16	*	0	*	*	0	*						
5	J0012+5431	dcm+23	*	0	*	*	0	*						
6	B0011+47	dth78	19.3	18	bfg+03	-19.7	15	bfg+03						
7	J0021-0909	clh+20	*	0	*	*	0	*						
8	J0023+0923	hrm+11	-11.00	7	bbc+24	-8.80	10	bbc+24						
9	B0021-72C	mld+90	5.25	3	vb21	-2.55	3	vb21						
10	B0021-72D	mlr+91	5.25	3	vb21	-2.55	3	vb21						
11	B0021-72E	mlr+91	5.25	3	vb21	-2.55	3	vb21						
12	B0021-72F	mlr+91	5.25	3	vb21	-2.55	3	vb21						
13	B0021-72G	rlm+95	5.25	3	vb21	-2.55	3	vb21						
14	B0021-72H	mlr+91	5.25	3	vb21	-2.55	3	vb21						
15	B0021-72I	mlr+91	5.25	3	vb21	-2.55	3	vb21						
16	B0021-72J	mlr+91	5.25	3	vb21	-2.55	3	vb21						
17	B0021-72L	rlm+95	5.25	3	vb21	-2.55	3	vb21						
18	B0021-72M	mlr+91	5.25	3	vb21	-2.55	3	vb21						
19	B0021-72N	rlm+95	5.25	3	vb21	-2.55	3	vb21						
20	J0024-7204O	clf+00	5.25	3	vb21	-2.55	3	vb21						
21	J0024-7204P	clf+00	5.25	3	vb21	-2.55	3	vb21						
22	J0024-7204Q	clf+00	5.25	3	vb21	-2.55	3	vb21						
23	J0024-7204R	clf+00	5.25	3	vb21	-2.55	3	vb21						
24	J0024-7204S	clf+00	5.25	3	vb21	-2.55	3	vb21						
25	J0024-7204T	clf+00	5.25	3	vb21	-2.55	3	vb21						
26	J0024-7204U	clf+00	5.25	3	vb21	-2.55	3	vb21						
27	J0024-7204V	clf+00	5.25	3	vb21	-2.55	3	vb21						

Welche Neutronensterne sind in Supernova-Überresten ?

Alter der SN-Überreste bestimmen

Vergleich mit Katalog der Supernova-Überreste

Galactic SNRs: Summary Data

2024 October version

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e also see the documentation for notes on the entries for each SNR in the catalogue, and for details of many possible and probabl
SNRs.

l /deg	b /deg	RA (J2000.0) /hh mm ss	Dec /dd mm	size /arcmin	type	1-GHz flux /Jy	spectral index	other name(s)
0.0	+0.0	17 45 44	-29 00	3.5x2.5	S	100?	0.8?	Sgr A East
0.3	+0.0	17 46 15	-28 38	15x8	S	22	0.6	
0.9	+0.1	17 47 21	-28 09	8	C	18?	varies	
1.0	-0.1	17 48 30	-28 09	8	S	15	0.6?	
1.4	-0.1	17 49 39	-27 46	10	S	2?	?	
1.9	+0.3	17 48 45	-27 10	1.5	S	0.6	0.6	
3.1	-0.6	17 55 30	-26 35	52x28	S	5	0.9?	
3.7	-0.2	17 55 26	-25 50	14x11	S	2.3	0.65	
3.8	+0.3	17 52 55	-25 28	18	S?	3?	0.6	
4.2	-3.5	18 08 55	-27 03	28	S	3.2?	0.6?	
4.5	+6.8	17 30 42	-21 29	3	S	19	0.64	Kepler, SN1604, 3C358
4.8	+6.2	17 33 25	-21 34	18	S	3	0.6	
5.2	-2.6	18 07 30	-25 45	18	S	2.6?	0.6?	
5.4	-1.2	18 02 10	-24 54	35	C?	35?	0.2?	Milne 56
5.5	+0.3	17 57 04	-24 00	15x12	S	5.5	0.7	
5.9	+3.1	17 47 20	-22 16	20	S	3.3?	0.4?	
6.1	+0.5	17 57 29	-23 25	18x12	S	4.5	0.9	
6.1	+1.2	17 54 55	-23 05	30x26	F	4.0?	0.3?	
6.4	-0.1	18 00 30	-23 26	48	C	310	varies	W28
6.4	+4.0	17 45 10	-21 22	31	S	1.3?	0.4?	
6.5	-0.4	18 02 11	-23 34	18	S	27	0.6	
7.0	-0.1	18 01 50	-22 54	15	S	2.5?	0.5?	
7.2	+0.2	18 01 07	-22 38	12	S	2.8	0.6	
7.5	-1.7	18 10 00	-23 10	100	S	18?	0.7?	
7.7	-3.7	18 17 25	-24 04	22	S	11	0.32	1814-24
8.7	-5.0	18 24 10	-23 48	26	S	4.4	0.3	
8.7	-0.1	18 05 30	-21 26	45	S?	80	0.5	(W30)
8.9	+0.4	18 03 58	-21 03	24	S	9	0.6	
9.7	-0.0	18 07 22	-20 35	15x11	S	3.7	0.6	
9.8	+0.6	18 05 08	-20 14	12	S	3.9	0.5	

Mögliche Bachelorarbeiten:

Entfernung von Supernova-Überresten *mit* Neutronensternen bestimmen

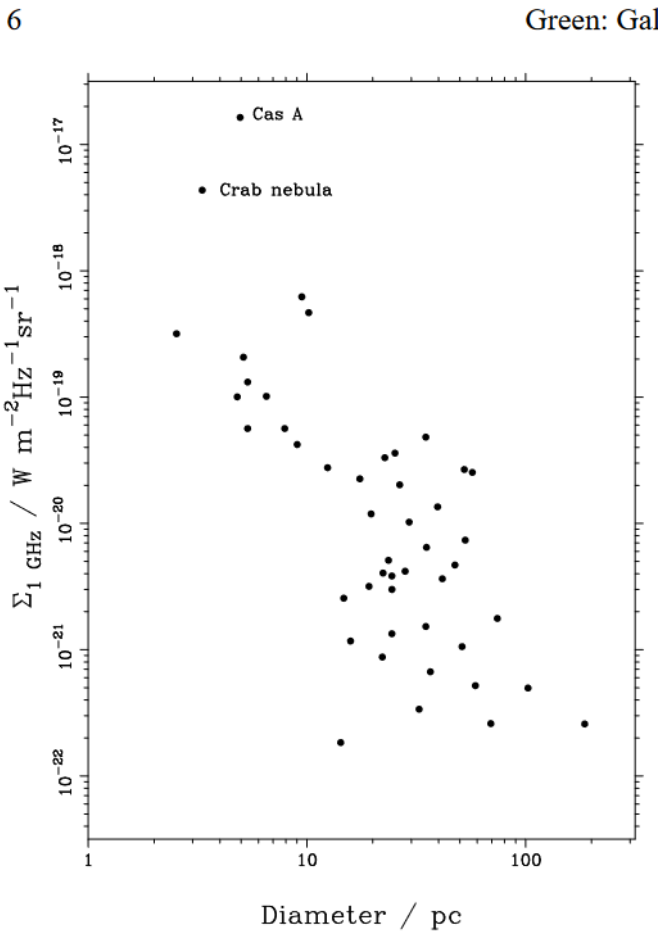
Mit der Stichprobe der Neutronensterne in Supernova-Überresten Σ – D Relation aufstellen :

Σ Oberflächenhelligkeit
(Radiohelligkeit und Winkeldurchmesser)

D Durchmesser
(Winkeldurchmesser und Entfernung)

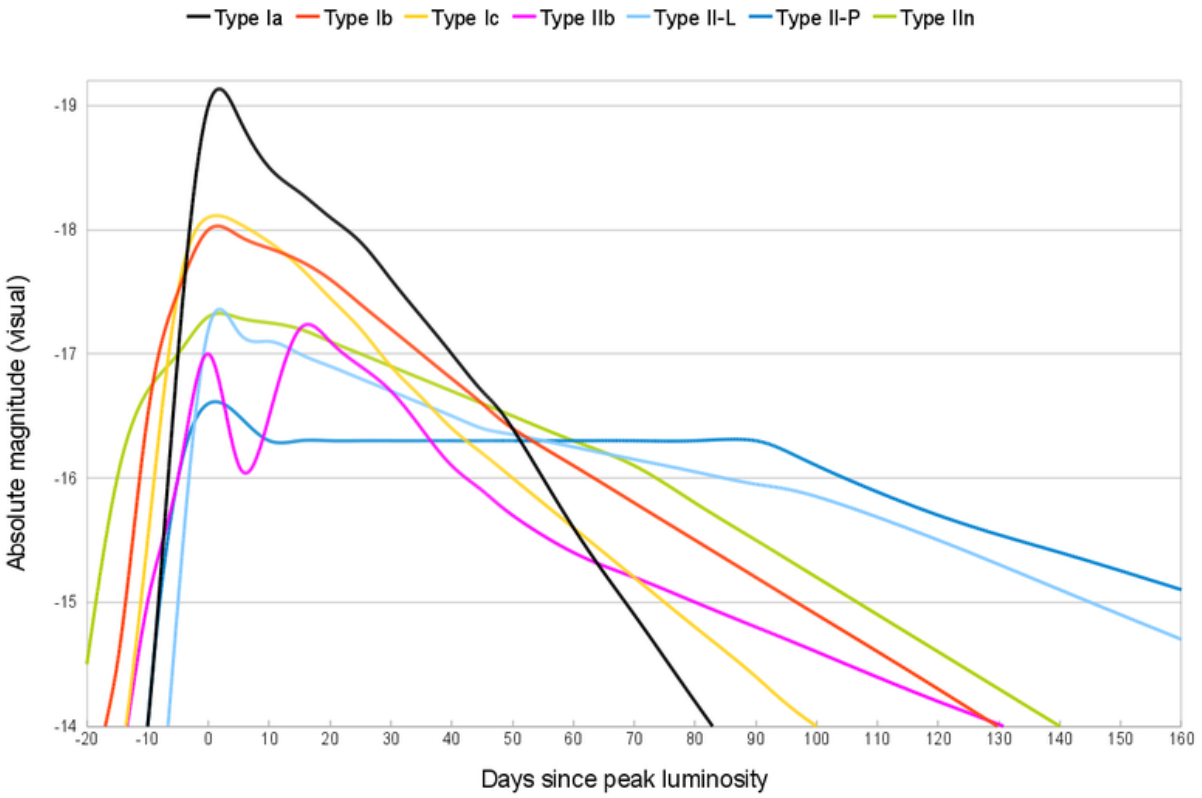
Also:
aus Radio-Helligkeit, Winkeldurchmesser und SN-Überresten mit anderweitig bekannten Entfernungen Σ – D Relation aufstellen

und dann damit Entfernungen anderer SN-Überreste bestimmen.



Versch. SN-Typen zeigen versch. Lichtkurven:

Absolute Magnituden:
M = -19.5 (SN Ia),
M = -20.3 (SN Ibc),
M = -17 mag (SN II-P)



Absolute Magnitude M ist scheinbare Magnitude m in 10 pc:

$M = m - 5 \log (r / 10\ pc) - A$

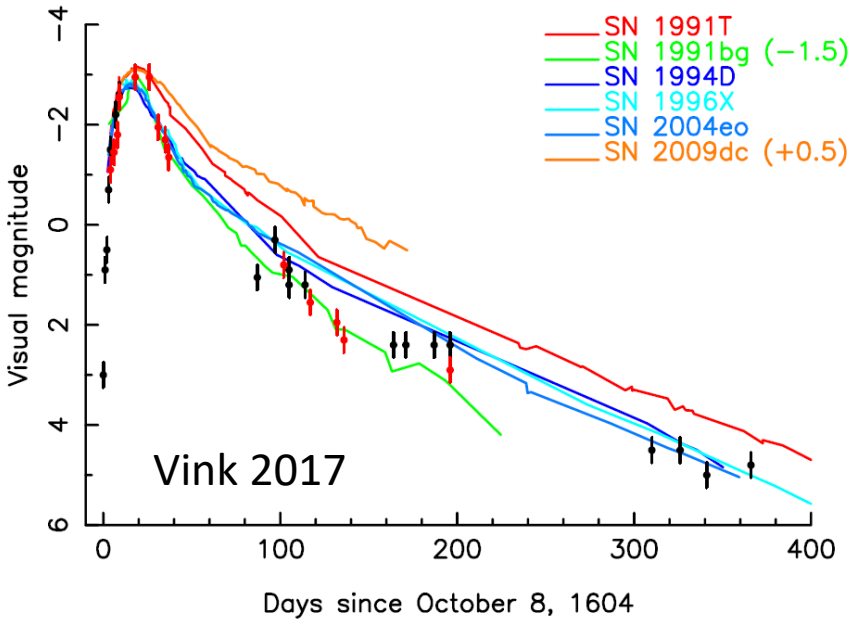
oder $M = m - 5 \log (r / pc) + 5 - A$

Entf. r in pc und Absorption A in mag, meist A_V

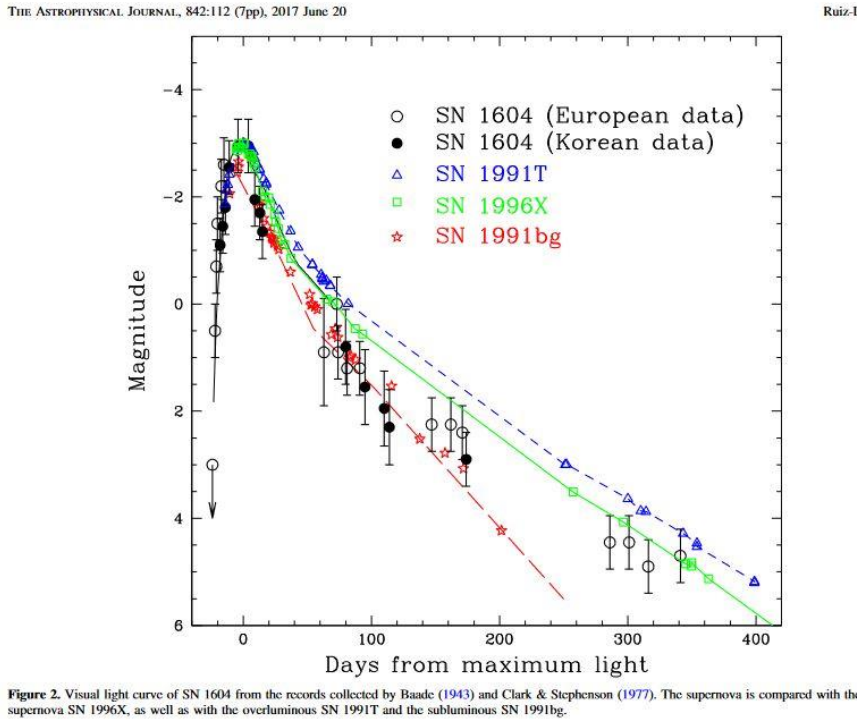
Mögliche Bachelorarbeiten:

Lichtkurven von verschiedenen Supernova-Typen

SN 1572 (Tycho Brahe)



SN 1604 (Kepler)



Aufgabe: aus Tausenden extra-galaktischer Supernovae für die verschiedenen Untertypen die typischen Lichtkurven und Farbentwicklungen bestimmen

Mögliche Bachelorarbeiten:

(1) Vergleich verschiedener Entfernungsbestimmungs-Methoden bei Neutronensternen

(2) Alter von Supernova-Überresten mit Neutronensternen darin bestimmen

(3) Entfernung von Supernova-Überresten bestimmen

(4) Lichtkurven von verschiedenen Supernova-Typen