Место рождения нейтронной звезды PSR J1932+1059 (B1929+10)

Бобылев В.В.

Главная астрономическая обсерватория в Пулкове

ИСТОРИЯ ВОПРОСА

1. Пояс Гулда

3. Пульсары и убегающие звезды

5. Пузыри

Нейтронные звезды и пояс Гулда

2006

Christian Motch · Adriana M. Pires · Frank Haberl · Axel Schwope

Measuring proper motions of isolated neutron stars with Chandra.

Constraints on the nature and origin of the ROSAT discovered isolated neutron stars

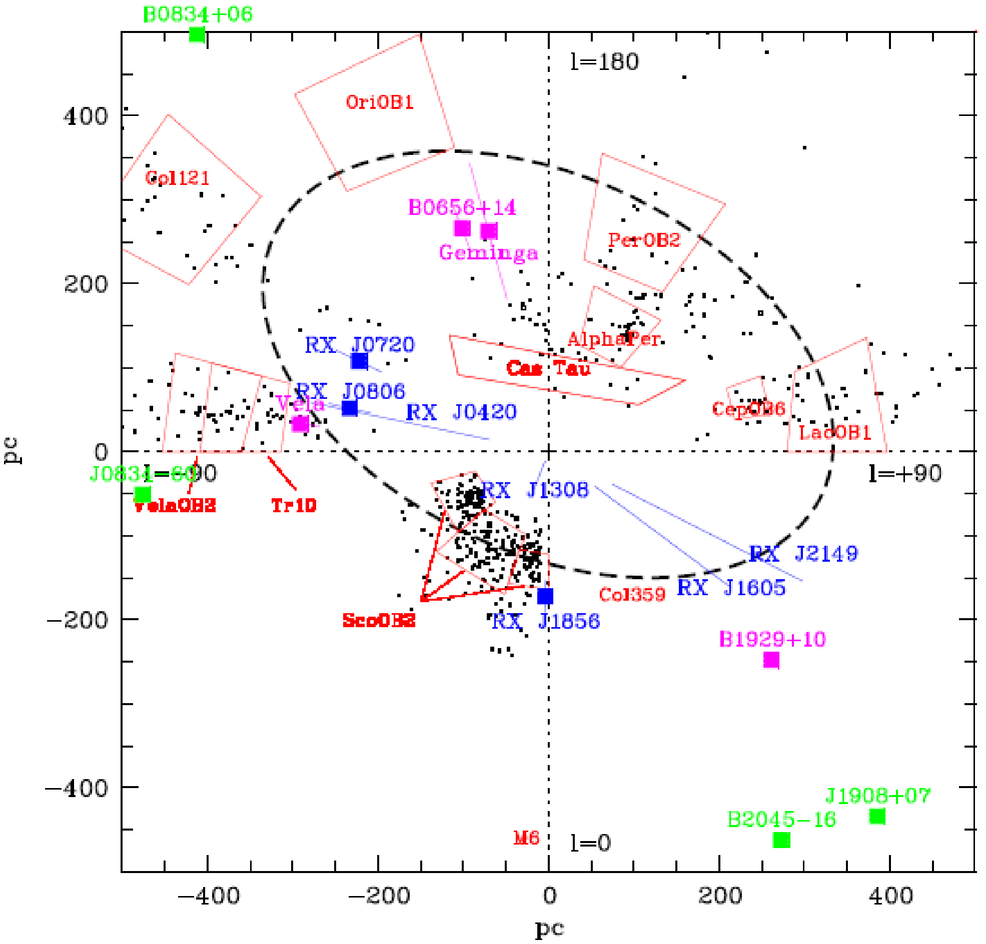

Fig. 3 Positions of nearby neutron stars and OB associations projected on the Galactic plane. Red boxes show the OB associations boundaries. Hipparcos stars with a probability higher than 75% to be linked to the OB associations are represented by black dots. Blue lines and filled squares show the possible positions of the ROSAT discovered INS, assuming a distance range of 100 to 400 pc for those which do not have distance estimates. Radio or γ-ray pulsars younger than 4.25 Myr and located within 1 kpc are shown as magenta symbols (when a parallax distance exists) or green symbols when the distance is estimated from dispersion measurements. The Gould Belt is shown as a thick dashed line.

On the origin of the O and B-type stars with high velocities II

Runaway stars and pulsars ejected from the nearby young stellar groups

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Sterrewacht Leiden, Postbus 9513, 2300 RA Leiden, the Netherlands

August 2000

ζ Oph

PSR B1929+10

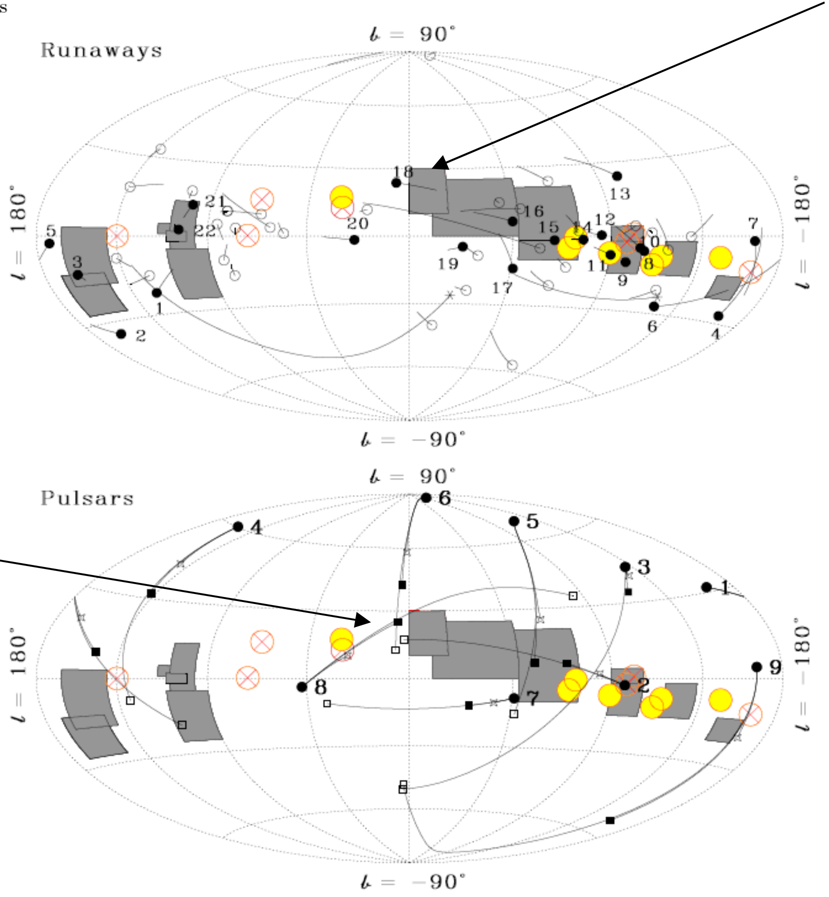

Fig. 2. *Top:* Sample of runaway stars defined in §2.1, in Galactic cordinates. The open circles denote the present positions of the runaways, and the arcs show their past orbits, calculated for 2 Myr. The filled circles are the runaways for which we can identify the parent association. The numbers refer to the entries in Table 3. The asterisks indicate two additional runaways (72 Col, HIP 94899 [left most of the two asterisks]) discussed in §7. The grey fields outline the nearby OB associations (de Zeeuw et al. 1999). From left to right and from top to bottom: Per OB3 (α Persei), Per OB2, Cep OB3, Cep OB2, Cep OB6, Lac OB1, Upper Scorpius, Upper Centaurus Lupus, Lower Centaurus Crux, Tr 10, Vel OB2, Col 121, and Ori OB1. The open clusters are identified by the filled light-grey circles for those with reliable positions and velocities, and by the open, crossed circles for the remaining clusters. The positions and designations of the clusters can be found in Table 2. *Bottom:* Pulsar sample defined in §2.1, in Galactic coordinates. The filled circles indicate the present positions of the pulsars. The past orbits of pulsars, calculated for 2 Myr, are shown for three different assumed radial velocities: 0 km s^{-1} (filled squares), 200 km s^{-1} (open squares), -200 km s^{-1} (open stars). The pulsars are labeled 1 through 8; 1: J0826+2637, 2: J0835−4510 (Vela pulsar), 3: J0953+0755, 4: J1115+5030, 5: J1136+1551, 6: J1239+2453, 7: J1456−6843, 8: J1932+1059. Number 9 is the neutron star Geminga. The associations and open clusters typically move comparatively little in 2 Myr.

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THE PROPER MOTION, PARALLAX, AND ORIGIN OF THE ISOLATED NEUTRON STAR RX J185635−3754

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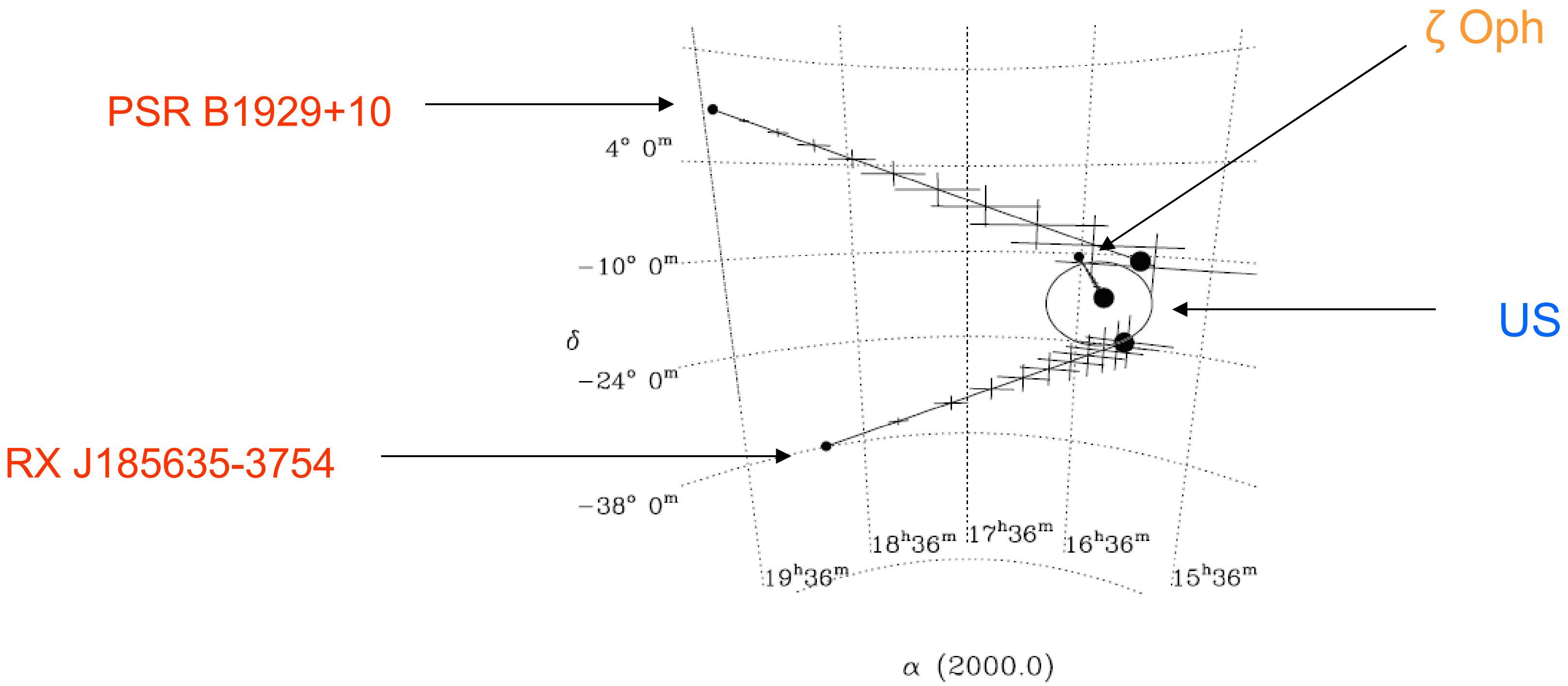

FIG. 5.—Apparent positions of the neutron star RX J185635−3754 (moving east-southeast), the pulsar B1929+10 (moving east-northeast), ζ Oph (declination −10°, moving north-northeast), and the Upper Sco association (declination −24°, moving south-southwest) projected backward in time. I use the assumed radial velocities of −60 and +160 km s^{-1} for RX J185635−3754 and PSR B1929+10 which yield the closest approaches to ζ Oph. The present positions are plotted as small filled circles; positions of B1929+10, ζ Oph, and RX J185635−3754 at times of closest approach are the large filled circles. The large open circle is the position and approximate size of the Upper Sco association at the time of closest approach. The uncertainties on the positions are estimated using the uncertainties in the distances, proper motions, and radial velocities and are plotted for the three stars at 10 points spaced linearly in time between 0.1 and 1.0 Myr in the past.

Северный полярный шпур

PASJ: Publ. Astron. Soc. Japan , 1–??,

Suzaku Observations of the North Polar Spur: Evidence for Nitrogen Enhancement

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John P. Hughes,[5] Satoru Katsuda,[2] Motohide Kokubun,[6] Kazuhisa Mitsuda,[4] F. Scott Porter,[7]
Yoh Takei,[4,8] Yohko Tsuboi,[9] Noriko Y. Yamasaki[4]

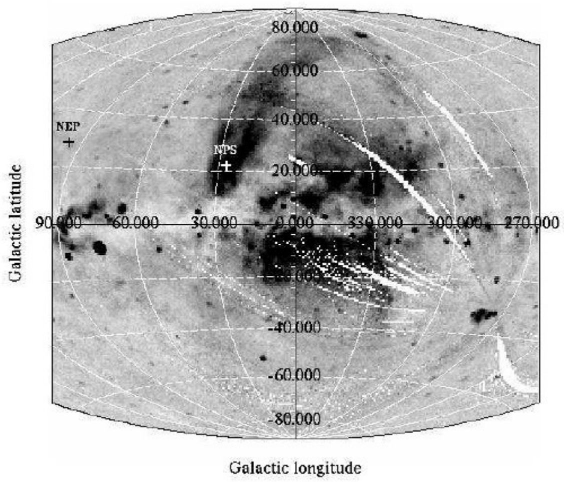

Fig. 1. *ROSAT* 3/4 keV map toward the Galactic center, shown in inverse grayscale (Snowden et al. 1997). The location of our *Suzaku* NPS pointing is indicated by the white cross. The location of the off-source NEP observation is shown by a black cross.

Mon. Not. R. Astron. Soc. **343,** 995–1001 (2003)

The X-ray spectrum of the North Polar Spur

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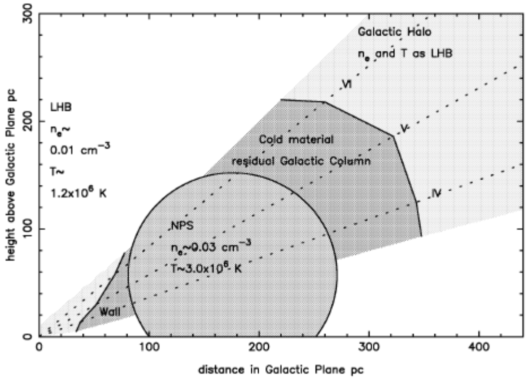

Figure 5. A schematic vertical slice through the Galactic plane at $l_{\rm II} = 20°$ indicating the extent of various hot and cold gaseous components. The lines of sight in fields IV, V and VI are shown as dotted lines.

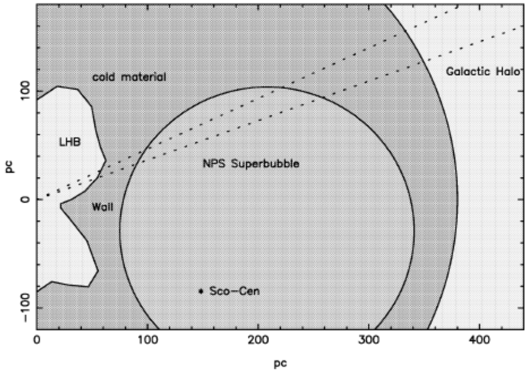

Figure 6. A schematic slice through the Galaxy tilted at an angle of 30° to the Galactic plane. The straight dotted lines indicate the line of sight of the NPS observations. The profile of the LHB is taken from the absorption model of HWW. The Sco–Cen OB association, which is usually taken as the centre of Loop I, is shown at a distance of 170 pc.

The History and Future of the Local and Loop I Bubbles

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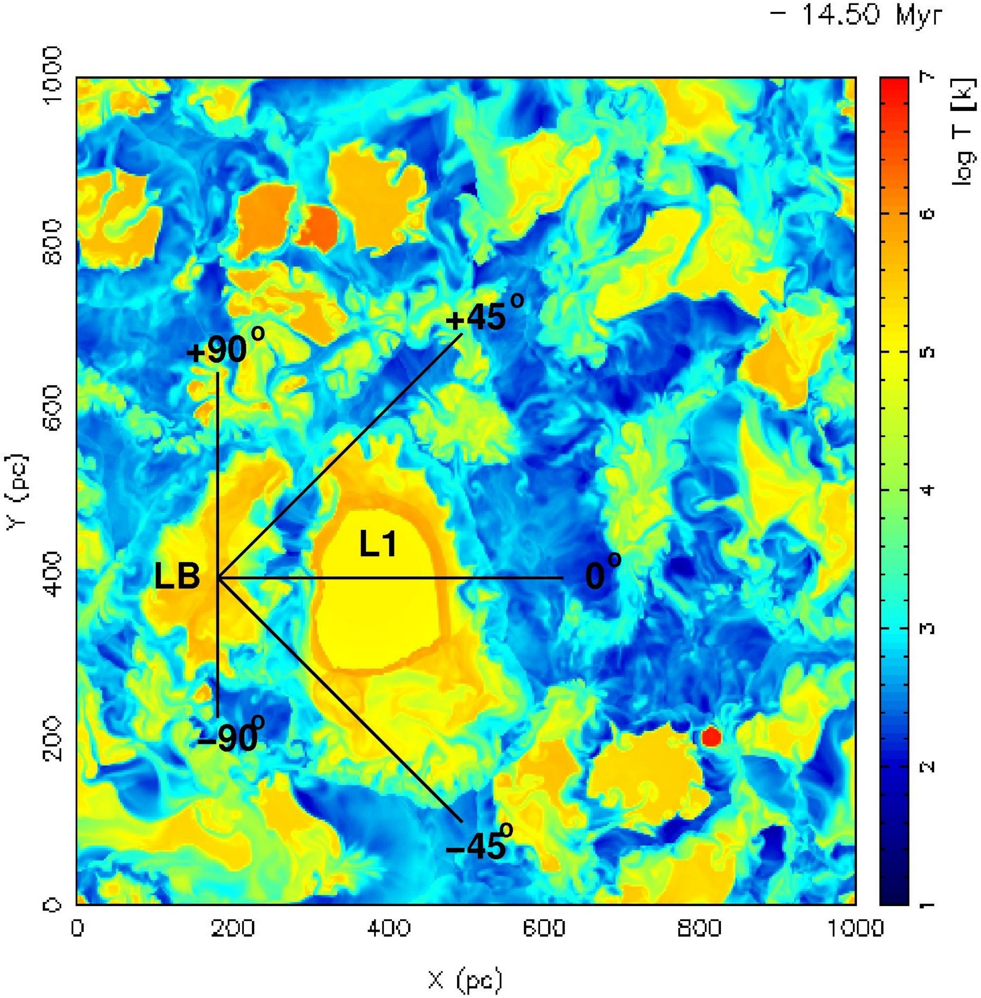


ЦЕЛИ И ЗАДАЧИ

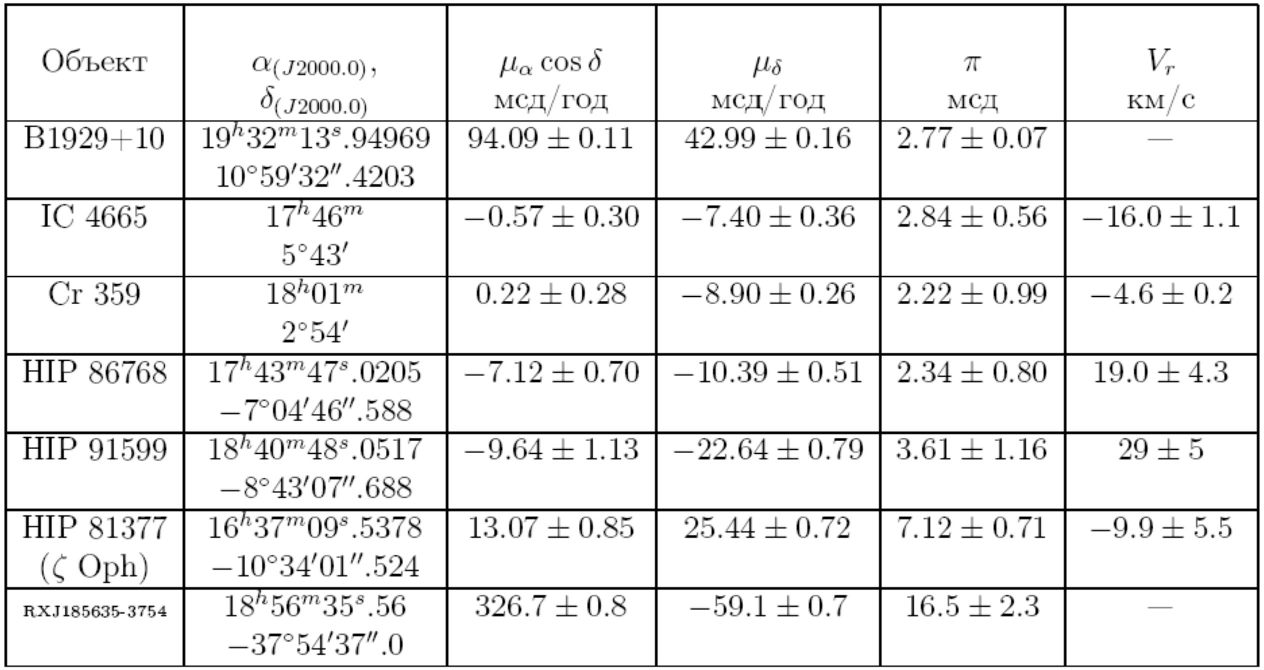
1. Проверка гапотезы Хугерверфа и др. (2001) о связи ζ Oph—PSR B1929+10 в окрестности US, и нашей гипотезы о рождении пульсара B1929+10 в окрестности IC 4665 в связи с новым значением параллакса пульсара

2. Установление эволюционной связи РСЗ IC 4665 и Cr 359 с ассоциацией Скорпиона-Центавра, а так же с Северным полярным шпуром

Данные

R.Hoogerwerf et al., 2001:
PSR B1929+10:

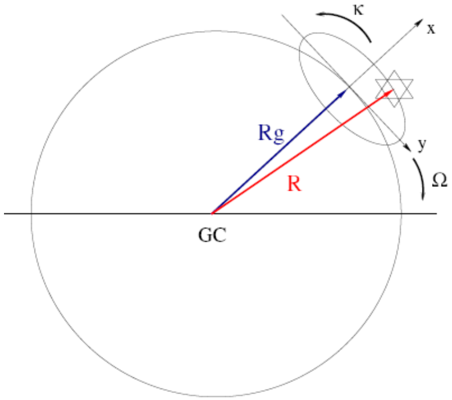
π = 4±2 mas
μ_al= 99±6 mas/yr
μ_dl= 39±8 mas/yr



Объект	$\alpha_{(J2000.0)}$, $\delta_{(J2000.0)}$	$\mu_\alpha \cos\delta$ мсд/год	μ_δ мсд/год	π мсд	V_r км/с
B1929+10	$19^h32^m13^s.94969$ $10°59'32''.4203$	94.09 ± 0.11	42.99 ± 0.16	2.77 ± 0.07	—
IC 4665	17^h46^m $5°43'$	-0.57 ± 0.30	-7.40 ± 0.36	2.84 ± 0.56	-16.0 ± 1.1
Cr 359	18^h01^m $2°54'$	0.22 ± 0.28	-8.90 ± 0.26	2.22 ± 0.99	-4.6 ± 0.2
HIP 86768	$17^h43^m47^s.0205$ $-7°04'46''.588$	-7.12 ± 0.70	-10.39 ± 0.51	2.34 ± 0.80	19.0 ± 4.3
HIP 91599	$18^h40^m48^s.0517$ $-8°43'07''.688$	-9.64 ± 1.13	-22.64 ± 0.79	3.61 ± 1.16	29 ± 5
HIP 81377 (ζ Oph)	$16^h37^m09^s.5378$ $-10°34'01''.524$	13.07 ± 0.85	25.44 ± 0.72	7.12 ± 0.71	-9.9 ± 5.5
RXJ185635-3754	$18^h56^m35^s.56$ $-37°54'37''.0$	326.7 ± 0.8	-59.1 ± 0.7	16.5 ± 2.3	—

МЕТОД

Метод эпициклического приближения (Линдблад, 1927; 1959) позволяет построить орбиты звезд в системе координат, вращающейся вокруг центра Галактики по круговой орбите.



$$\begin{aligned} X(t) &= X(0) + \frac{U(0)}{\kappa}\sin(\kappa t) - \frac{V(0)}{-2B}(1-\cos(\kappa t)), \qquad (1)\\ Y(t) &= Y(0) +\\ &+2A\Big(X(0) - \frac{V(0)}{-2B}(1-\cos(\kappa t))\Big)t + \frac{\Omega_0}{-B\kappa}V(0)\sin(\kappa t) + \frac{2\Omega_0}{\kappa^2}U(0)(1-\cos(\kappa t)),\\ Z(t) &= \frac{W(0)}{\nu}\sin(\nu t) + Z(0)\cos(\nu t), \end{aligned}$$

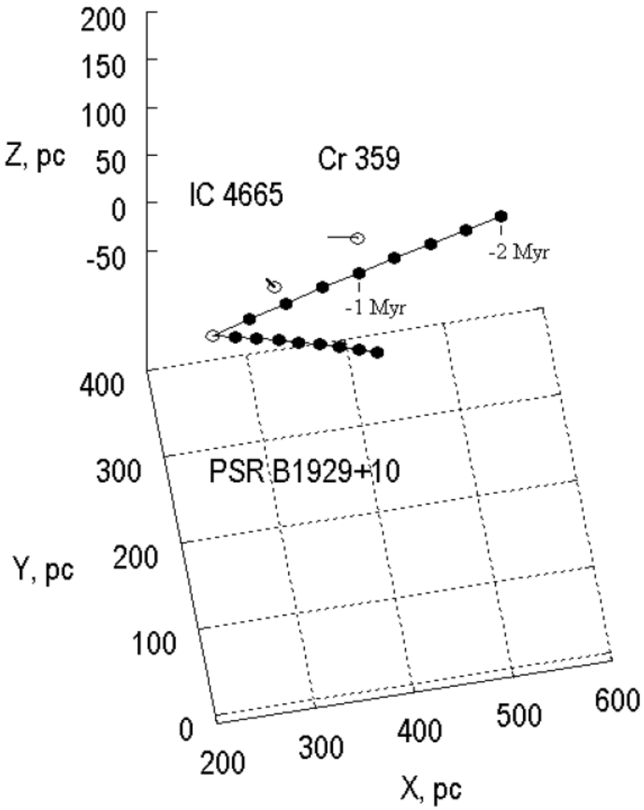
где t — время в млн. лет (исходим из соотношения пк/млн.лет=0.978 км/с), которое мы отсчитываем в прошлое; κ — эпициклическая частота, $\kappa = \sqrt{-4\Omega_0 B}$; A и B — постоянные Оорта, Ω_0 — угловая скорость галактического вращения местного стандарта покоя, $\Omega_0 = A - B$; ν — частота вертикальных колебаний, $\nu = \sqrt{4\pi G\rho_0}$, где G — гравитационная постоянная, а ρ_0 есть звездная плотность в околосолнечной окрестности. Пространственные скорости объектов вычисляются на любой необходимый момент времени по формулам

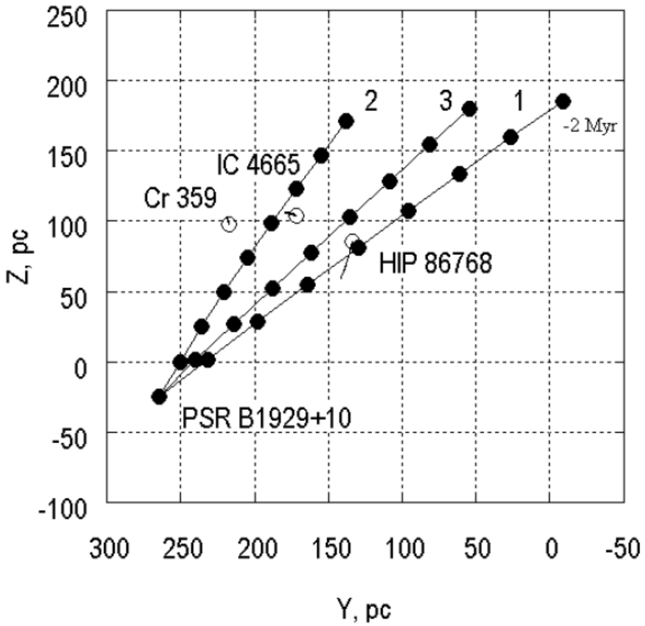
$$\begin{aligned} U(t) &= U(0)\cos(\kappa t) - \frac{\kappa}{-2B}V(0)\sin(\kappa t), \qquad (2)\\ V(t) &= \frac{-2B}{\kappa}U(0)\sin(\kappa t) + V(0)\cos(\kappa t),\\ W(t) &= W(0)\cos(\nu t) - Z(0)\nu\sin(\nu t). \end{aligned}$$

$X(0), Y(0), Z(0)$ и $U(0), V(0), W(0)$ в уравнениях (1)–(2) обозначают современные положения и скорости объектов. Скорости U, V, W мы даем относительно местного стандарта покоя, имеющего параметры $(U, V, W)_{LSR} = (10.00, 5.25, 7.17) \pm (0.36, 0.62, 0.38)$ км/с (Денен, Бинни, 1998). Следуя Фуксу и др. (2006), мы приняли $\rho_0 = 0.1\ M_\odot/\text{пк}^3$, что дает $\kappa = 0.039$ км/с/пк и $\nu = 0.074$ км/с/пк. Приняты так же следующие значения постоянных Оорта $A = 13.7 \pm 0.6$ км/с/кпк и $B = -12.9 \pm 0.4$ км/с/кпк, которые были найдены в работе Бобылева (2004) из анализа независимых определений этих параметров различными авторами.

РЕЗУЛЬТАТЫ

Сближения центров





1 — Vr (PSR)=+45 км/сек,
2 — Vr (PSR)=-60 км/сек,
3 — Vr (PSR)= 0 км/сек

IC 4665-PSR,
Cr 359-PSR:

Δr ≈ 50±50 пк
t ≈ -0.9 Myr

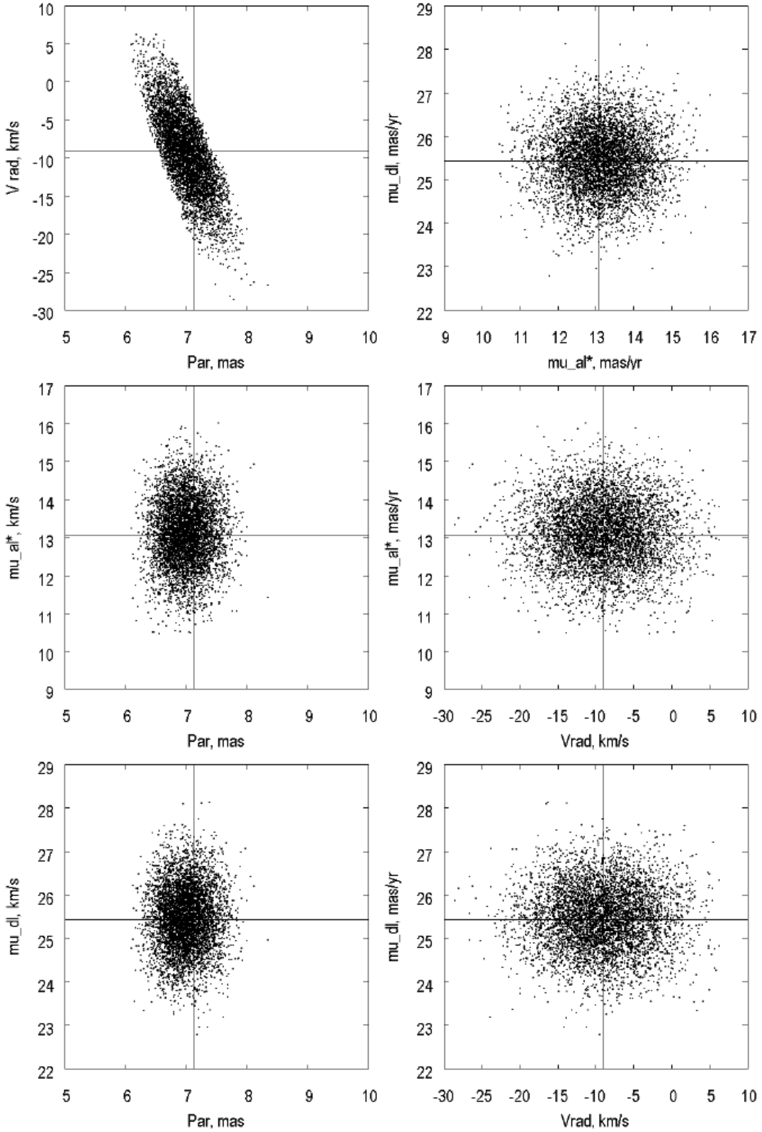
HIP 86768-PSR:

Vr (PSR)= 2 км/сек
Δr ≈ 20 пк
t ≈ -1 Myr

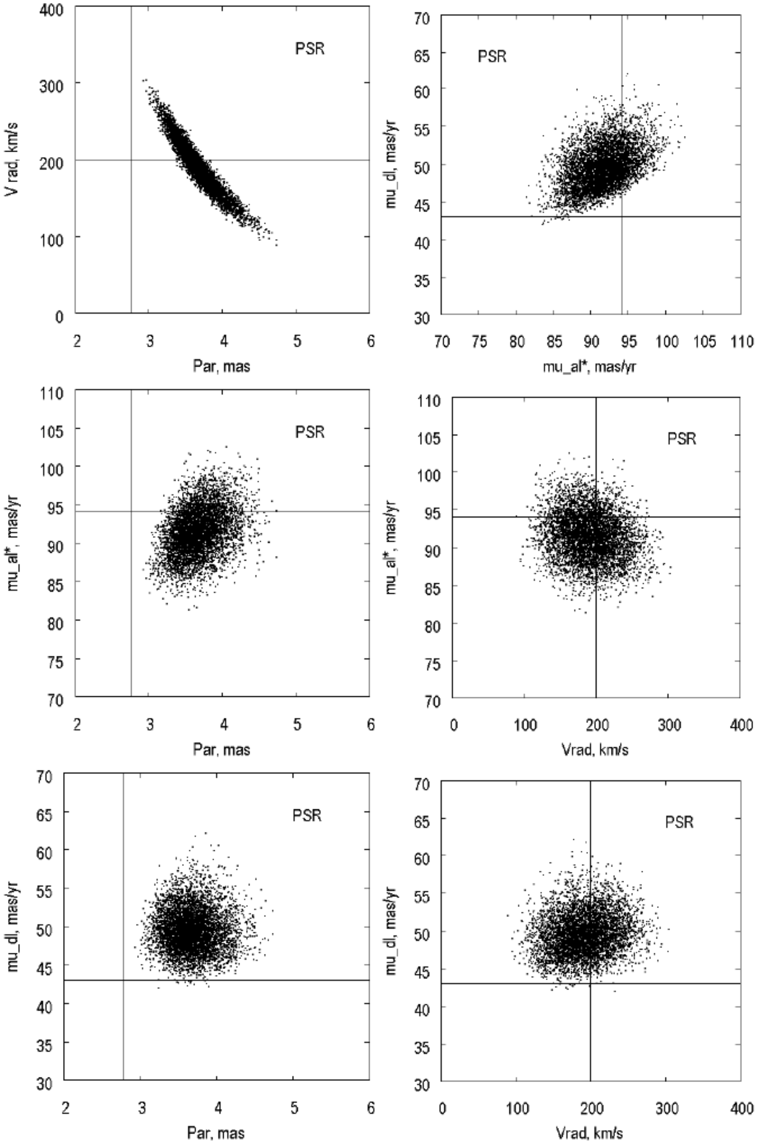
Вариант Хугерверфа и др.

Метод Монте-Карло

ζ Oph



PSR B1929+10



Вариант Хугерверфа и др.

ζ Oph-PSR B1929+10(J1932+1059)

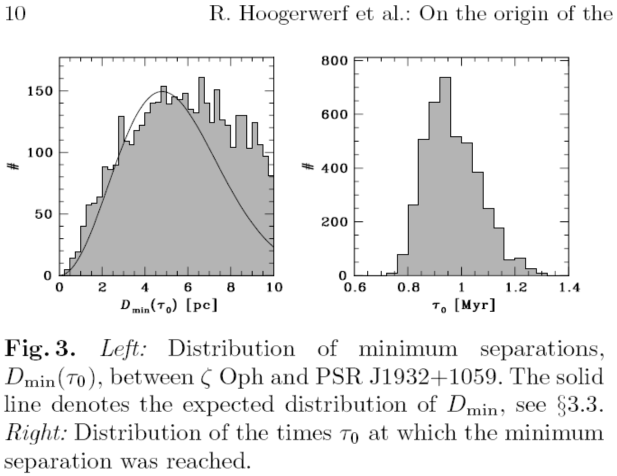
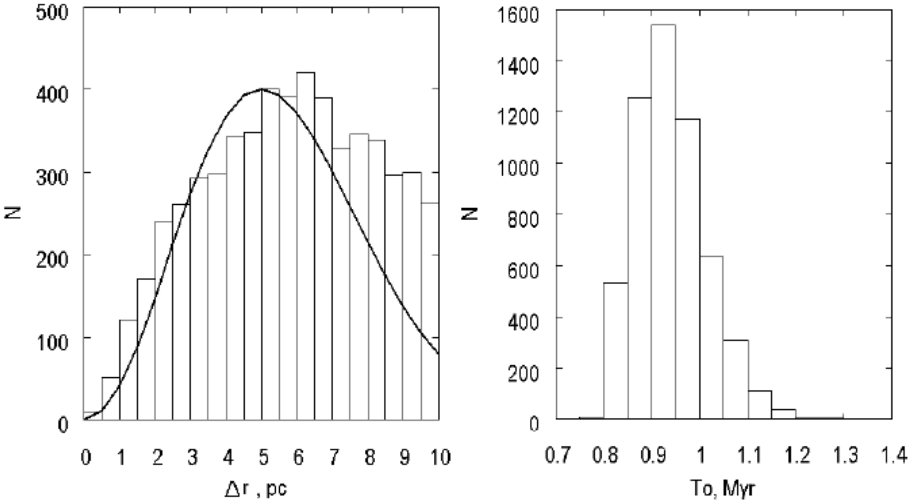

10 R. Hoogerwerf et al.: On the origin of the

Fig. 3. *Left:* Distribution of minimum separations, $D_{\min}(\tau_0)$, between ζ Oph and PSR J1932+1059. The solid line denotes the expected distribution of $D_{\min}$, see §3.3. *Right:* Distribution of the times τ_0 at which the minimum separation was reached.

В работе Хугерверфа и др. (2001) было получено:
30 822 / 3 000 000 = 1.4% сближений до Δr<10 пк

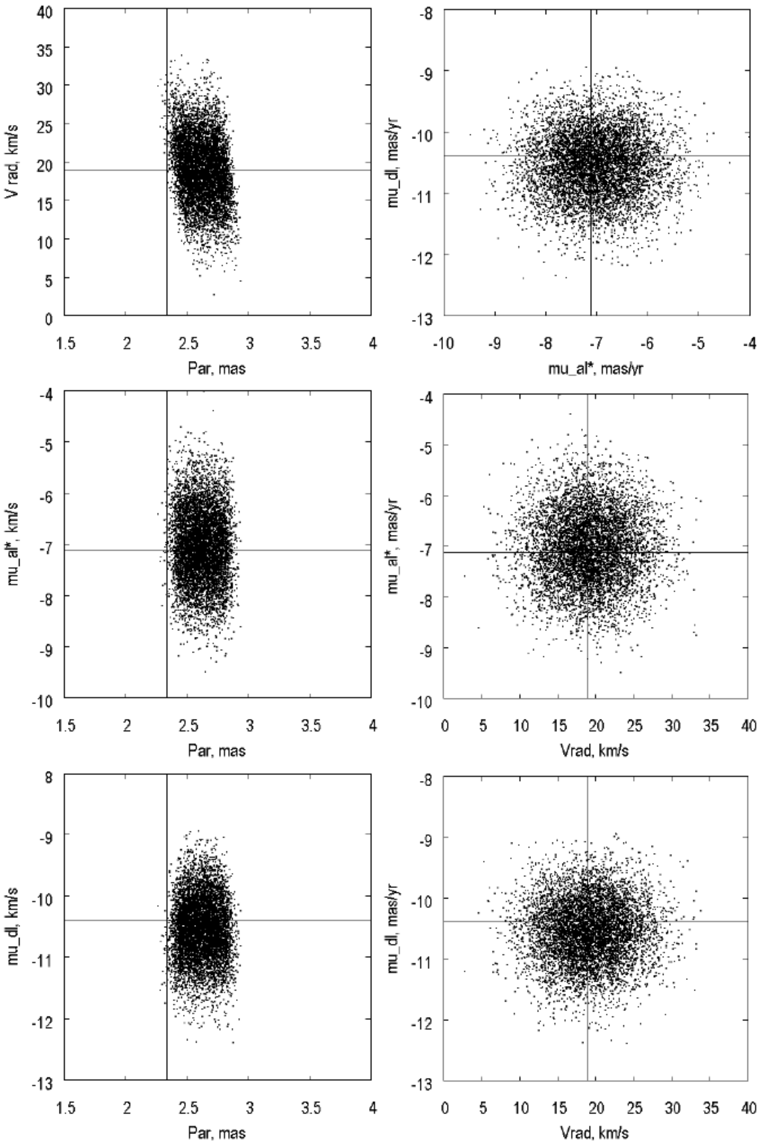


$$F_{3D}(\Delta_r) = \frac{\Delta_r^2}{2\sigma^3\sqrt{\pi}} \exp\left[-\frac{\Delta_r^2}{4\sigma^2}\right]$$

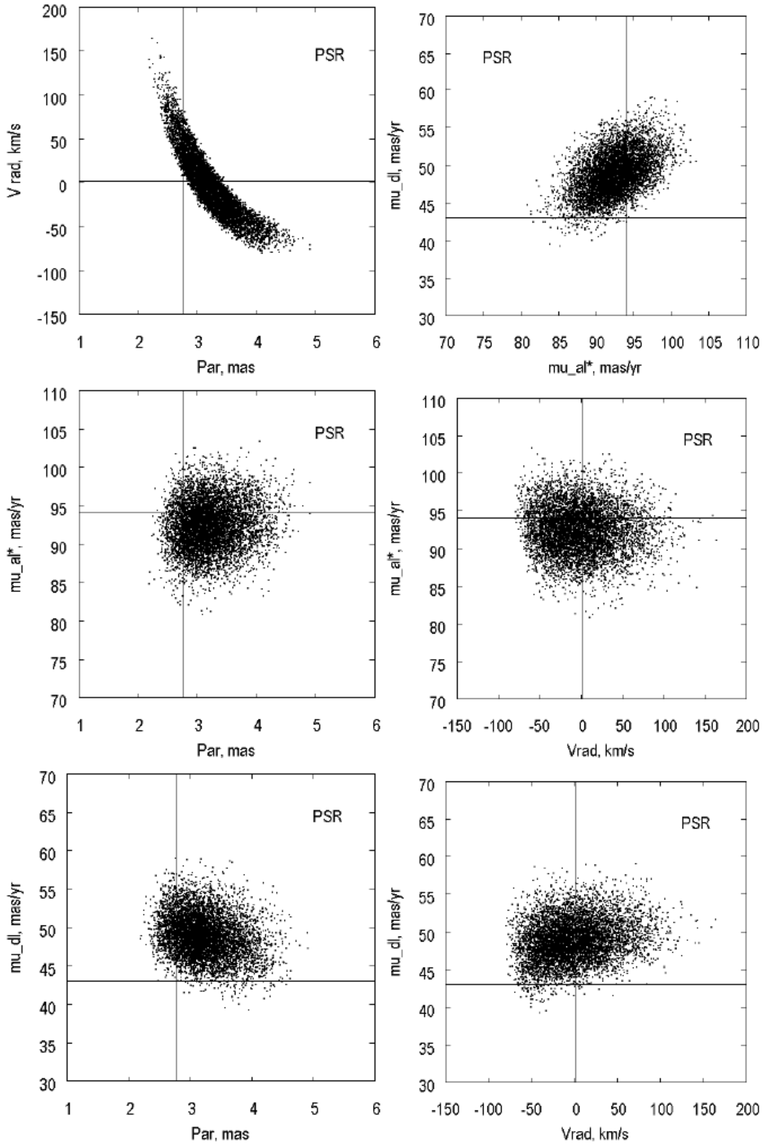
σ = 2.5 пк

74 115 / 3 000 000 = 2.5% сближений до Δr<10 пк

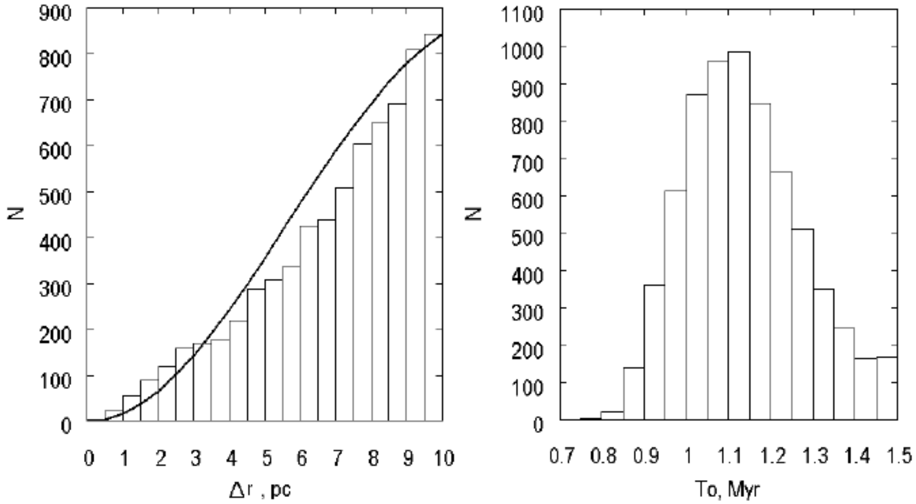
HIP 86768



PSR B1929+10



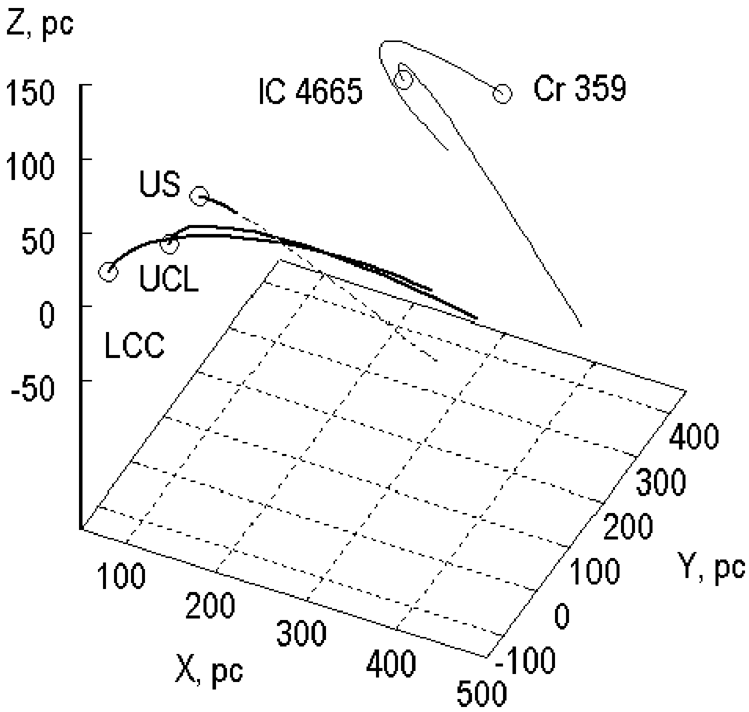
HIP 86768-PSR B1929+10



$$F_{3D}(\Delta_r) = \frac{\Delta_r^2}{2\sigma^3\sqrt{\pi}} \exp\left[-\frac{\Delta_r^2}{4\sigma^2}\right]$$

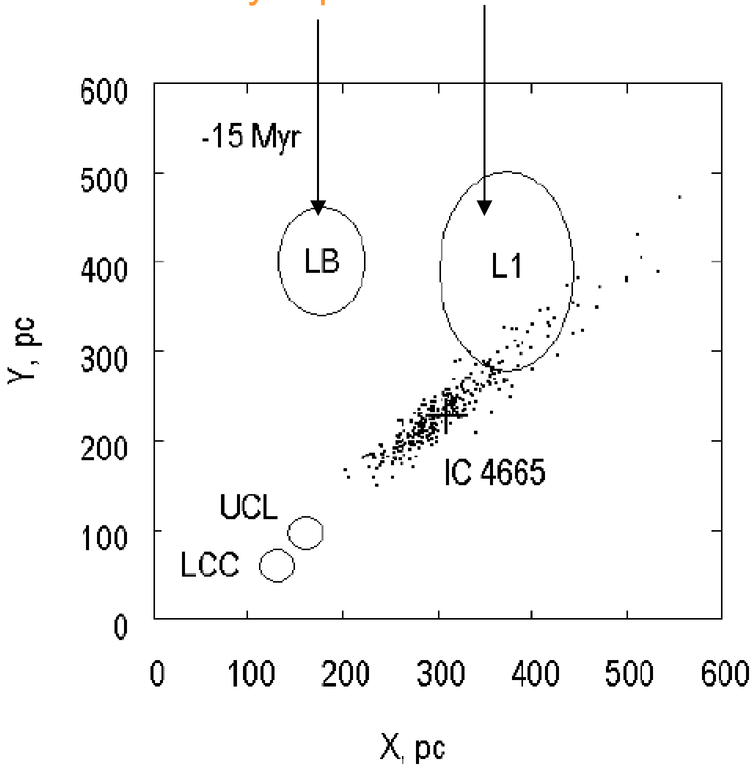
$\sigma = 6$ пк

22 708 / 3 000 000 = 0.8% сближений до $\Delta r<10$ пк


Z, pc
150
100
50
0
-50
US
UCL
LCC
IC 4665
Cr 359
100
200
300
400
500
X, pc
-100
0
100
200
300
400
Y, pc

Местный пузырь

Северный полярный шпур



ВЫВОДЫ

2. Вариант Хугерверфа и др (2001) с новыми данными для пульсара PSR B1929+10—ζ Oph наиболее вероятен
   74 115 / 3 000 000 = 2.5% сближений до Δr<10 пк
   Вариант PSR B1929+HIP 86768 на втором месте
   22 708 / 3 000 000 = 0.8%
   Вариант Волтера (2001) RX J185635-3754—ζ Oph
   2 144 / 3 000 000 = 0.07%

2. РСЗ IC 4665 в последние 10-15 млн лет всегда располагалось вблизи Северного полярного шпура (150-200 пк), поэтому взрывы сверхновых в IC 4665 могли оказывать влияние на характер формирования петли L1

Спасибо за внимание