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THE EVOLUTION OF THE PLANETARY NEBULAE ENSEMBLES IN THE LOCAL GROUP GALAXIES

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Tool: A new catalog of the planetary nebulae data

http://www.astro.spbu.ru/staff/afk/GalChemEvol.html

- A homogeneous set of the planetary nebulae (PNe) parameters and chemical abundances was compiled using **our calculations** and literature data.
- The optimal parameters (T_e, n_e, t^2) and He, C, N and O abundances was calculated for more than 120 PNe of the Galaxy and Magellanic Clouds (about 300 Galactic and MC PNe with their galactic coordinates, Peimbert's types, heliocentric distances, heights above the Galactic plane, masses of the central stars and He, C, N, O, Ne, S, Cl and Ar abundances).

Disadvantages:

- Relatively small number of objects (about of 2000 known in Galaxy, more than 500 in LMC and SMC)
- Huge uncertainty in the distances to Galactic PNe
- Strongly inhomogeneous structure with temperature and density fluctuations

PNe distances renormalization (calibration)

- Cahn & Kaler (1971)
- Acker (1978)
- Cahn, Kaler, Stanghellini (1992)
- Phillips (2004)

$$G_{Sc} = \frac{R_0^{(known)}}{R_0^{(obtained)}}$$

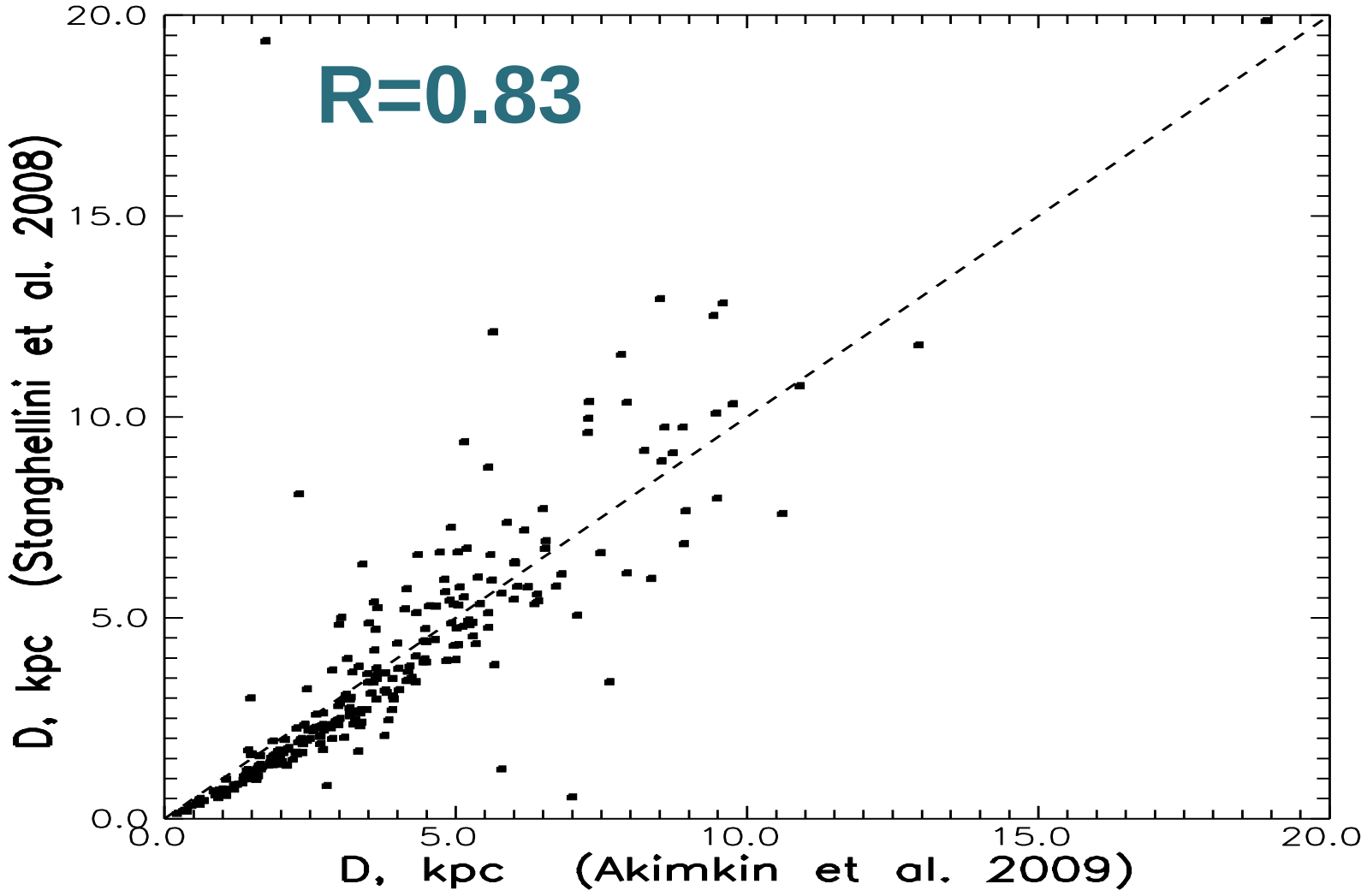
$$R_0^{(known)} = 7.9 \pm 0.2 \ \text{kpc}$$

Catalog	Nmb of PNe	$<R_0>$, kpc	G_{Sc}
CaKa-71	252	5.8 +/-0.3	1.36
Ac-78	233	5.4 +/-0.4	1.47
CKS-92	277	5.7 +/-0.4	1.40
Ph-04	219	6.7 +/-0.5	1.16

A new catalogue of the corrected distances contains of 320 Galactic PNe

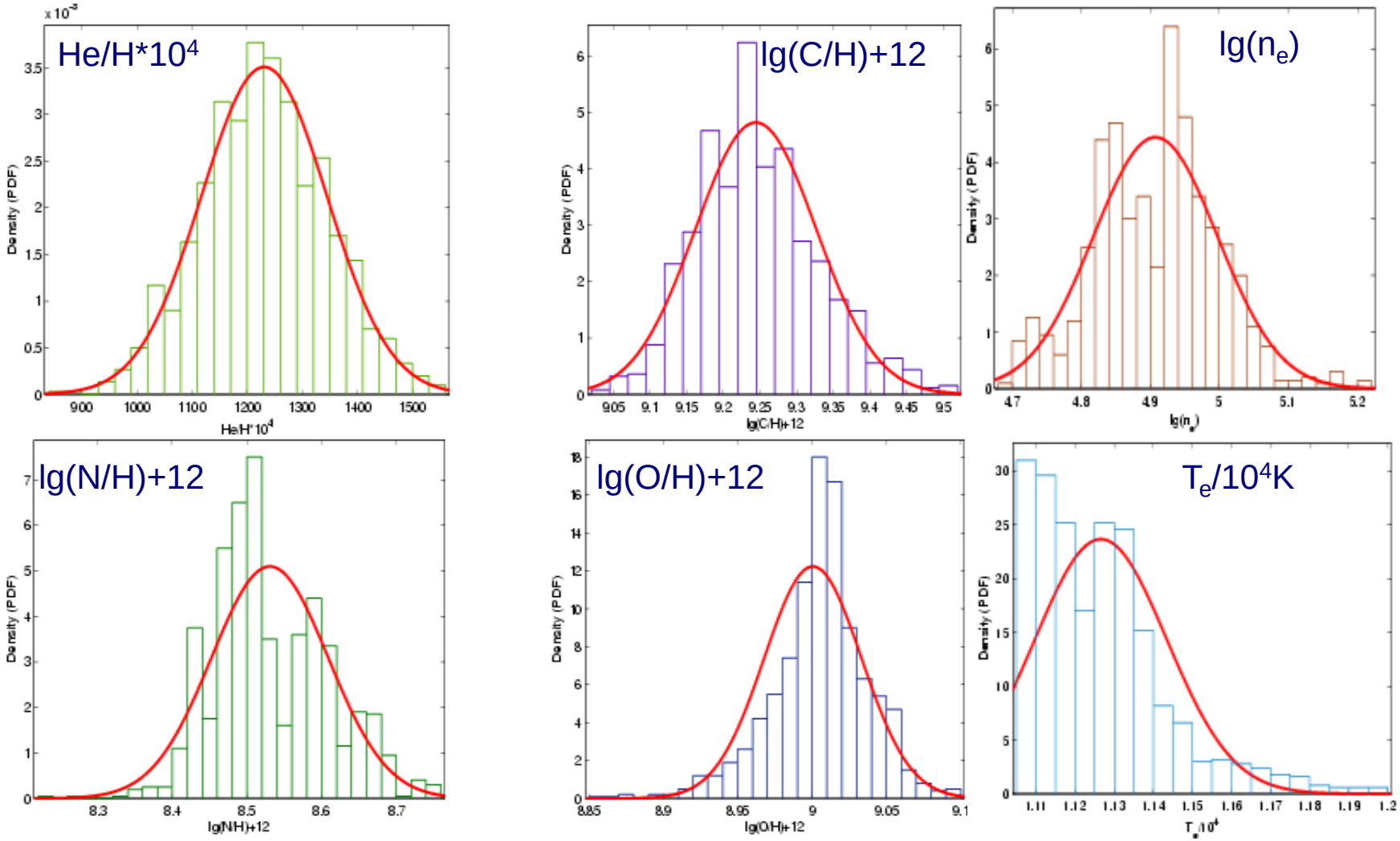
PNe	l	b	V_r, km/s	CaKa71	Ac78	CKS92	Ph04	r_{eff}	R_0	|z|
IC 4634	0.3	12.2	-33.1	5.17	4.32	3.88	-	4.46	3.54	0.94
SwSt 1	1.5	-6.7	-18.6	-	4.70	1.92	-	3.31	4.61	0.39
IC 5117	89.8	-5.1	-26.1	10.58	3.35	1.86	5.81	5.40	9.54	0.48

Renormalization of distances

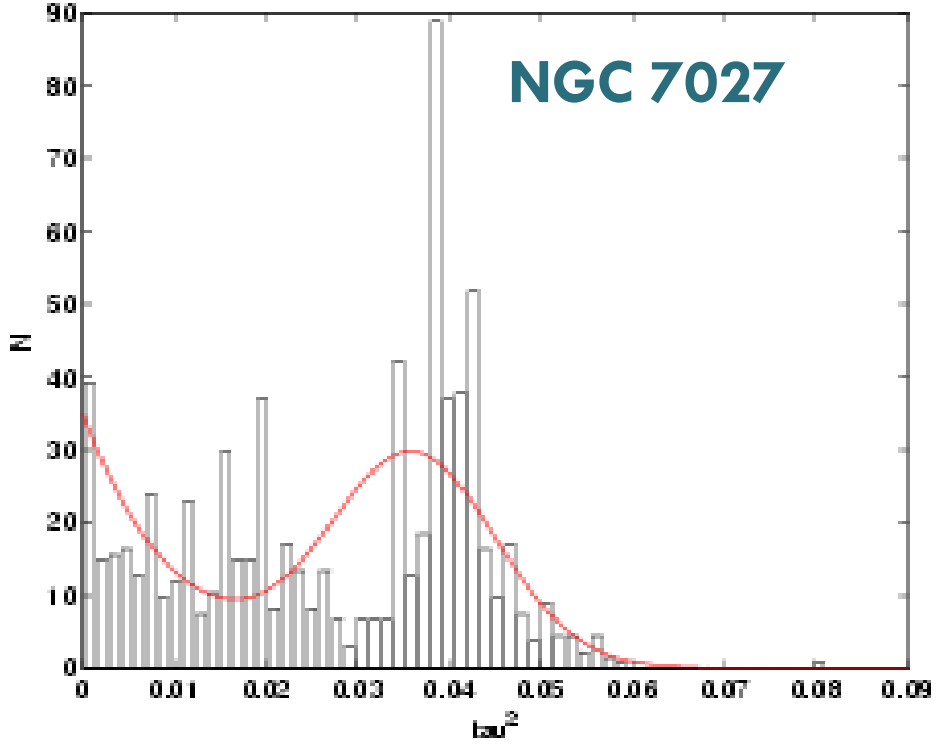


Are the PNe's parameters exact? Error simulation

- The set of N=1000 random vectors of line intensities $\{I^{obs}\}$ defines with N=1000 random values (PNe parameters - T_e, n_e, t^2, chemical abundances). Their distribution functions are plotted.



Error modelling of the parameter t^2



Errors in parameters

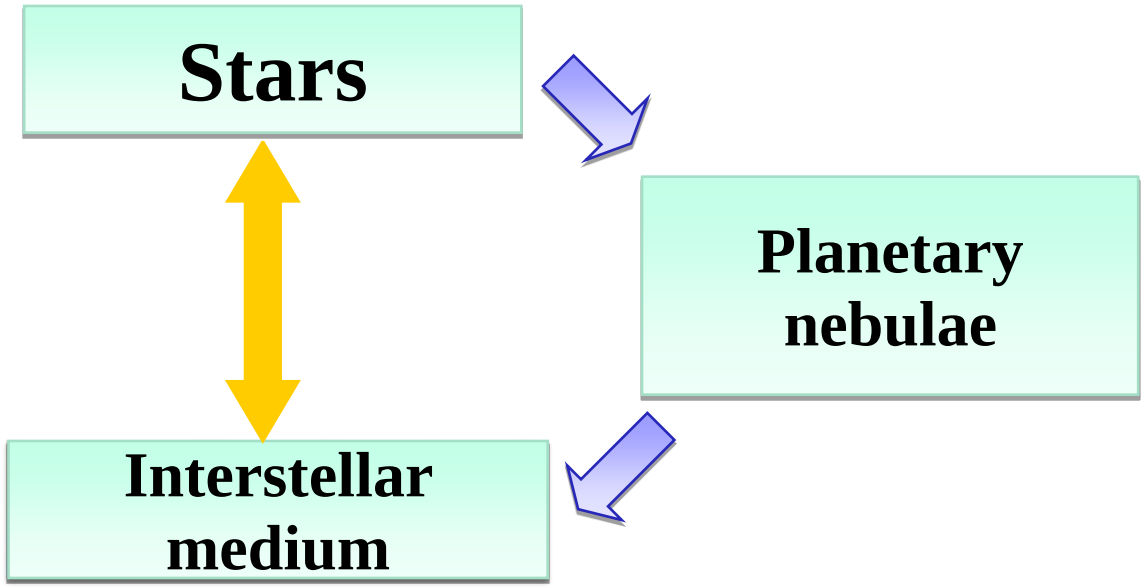
The uncertainties due to	He	CNO
Errors in the observed line intensities	10-15%	0.1 dex
Errors in ionization correction factors	0.1-0.2 dex	0.3 dex

large-scale + small-scale fluctuations of electron temperature

$$f(t^2) = 35e^{-0.01t^2} + 29e^{-[0.5(t^2-0.036)/0.009]^2}$$

Star formation history

- The research of the properties and chemical evolution of the ensemble of Galactic and Magellanic Cloud's planetary nebulae



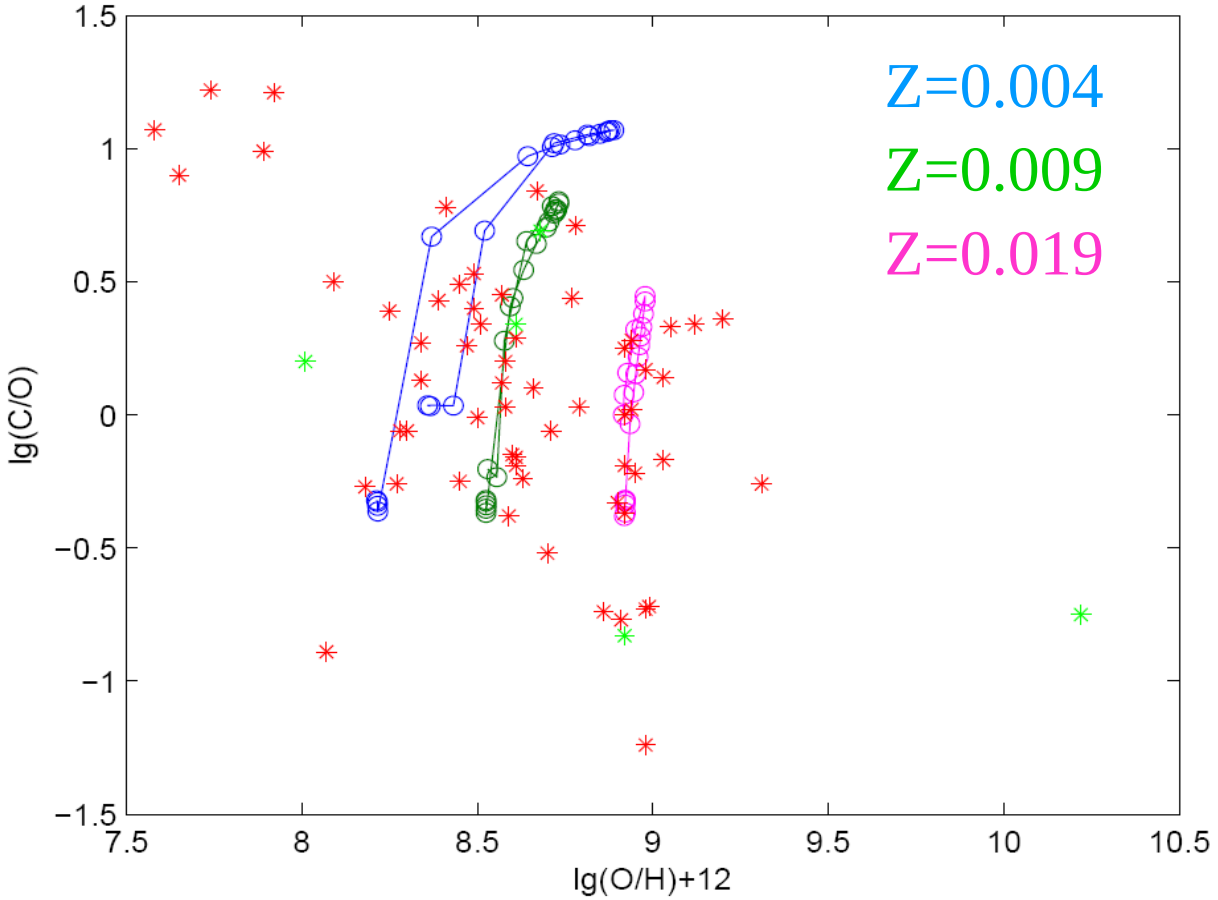
Star formation history in the Galactic disk, bulge and Magellanic Clouds

Next problems are considered:

- The comparison of the chemical abundance of the PNe ensemble with the synthetic models of the LIMS evolution.
- PNe with the extremely low abundances of C, N, O and other elements.
- A comparison of the abundances in the different galactic subsystems.
- A comparison of the abundances for nebulae in our Galaxy and in the Magellanic Clouds.
- Determination of abundance gradients for the Milky Way PNe ensembles both for all galactic PNe and for nebulae with the different ages of their progenitors.
- Investigation of the evolution of the element abundances in the different regions of the Milky Way in a comparison with the modern models of the Galaxy chemical evolution.

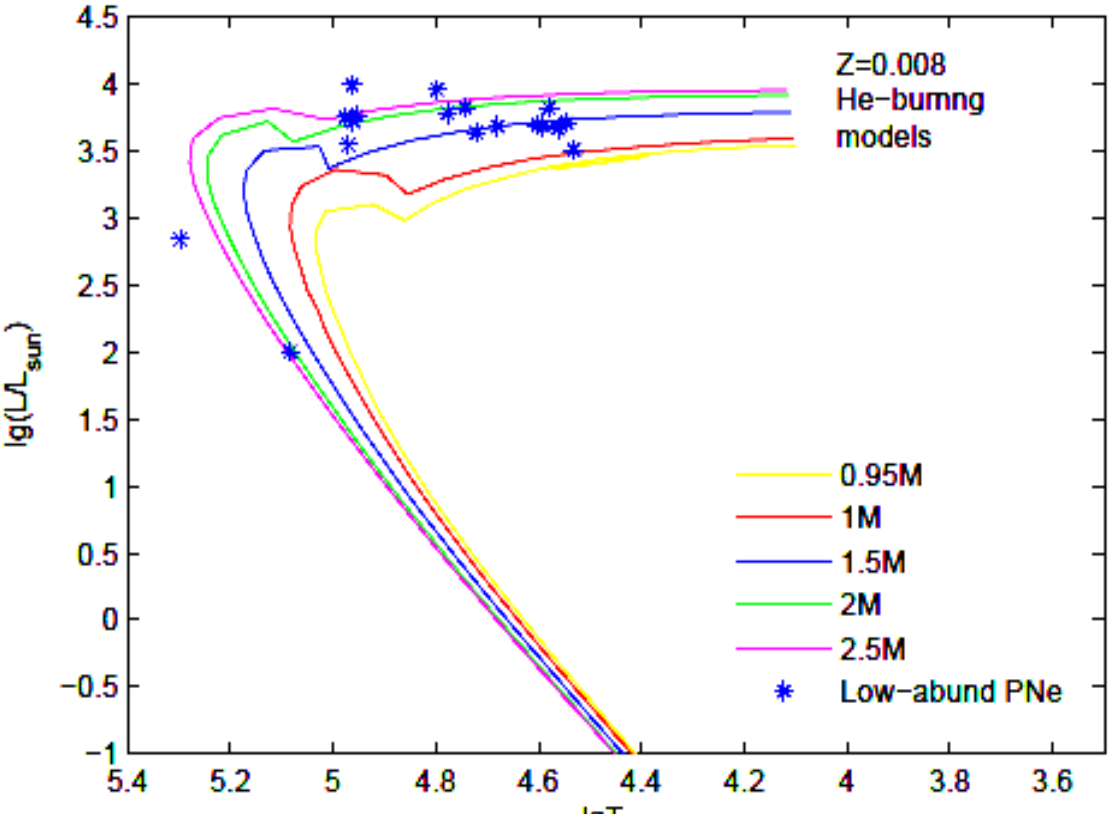
Comparison of the C, N, O relative abundances in PNe ensemble and those calculated in the synthetic evolution models of LIMS

- The predicted abundances (model from Marigo, 2001) for the stars with different initial masses and metallicities



Low-abundance planetary nebulae.

Are they the low masses halo objects?

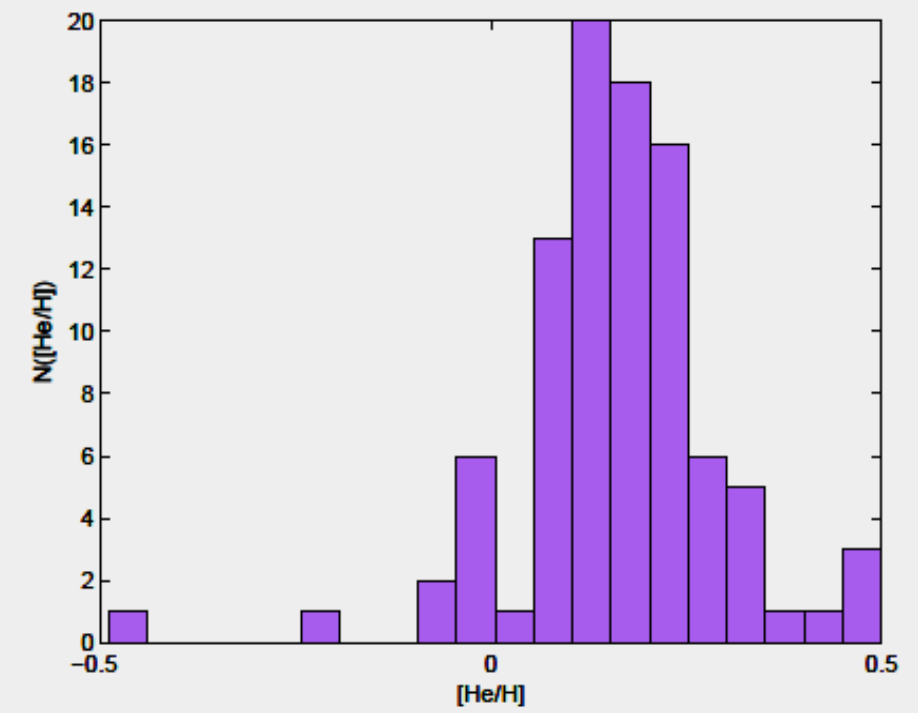


The model tracks from
Vassiliadis, Wood (1994)
Z=0.008

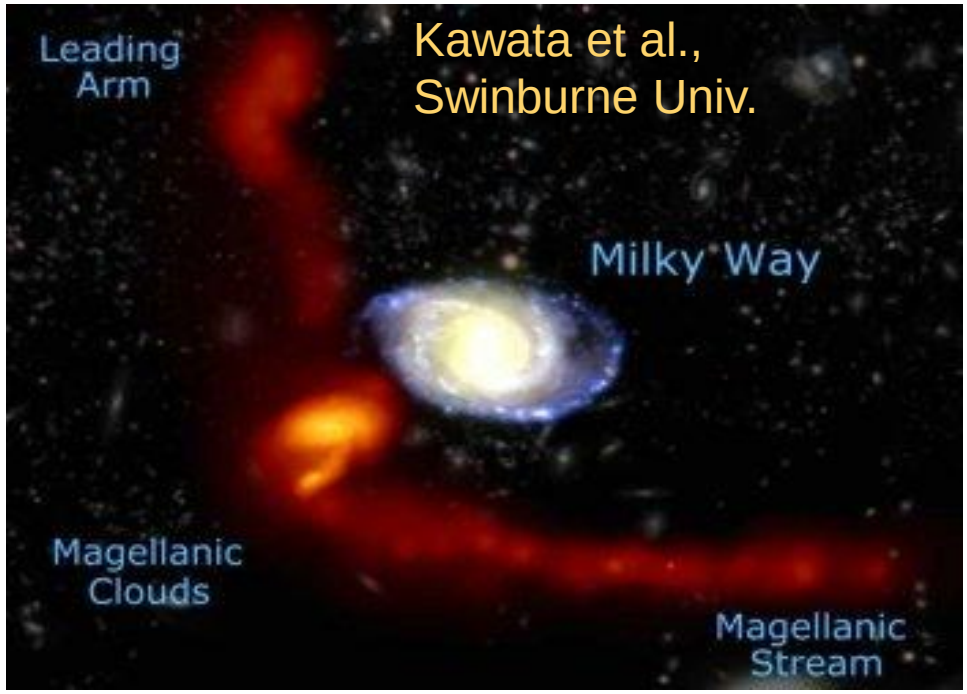
[X]<-1.0, or for more than two elements [X]<-0.5

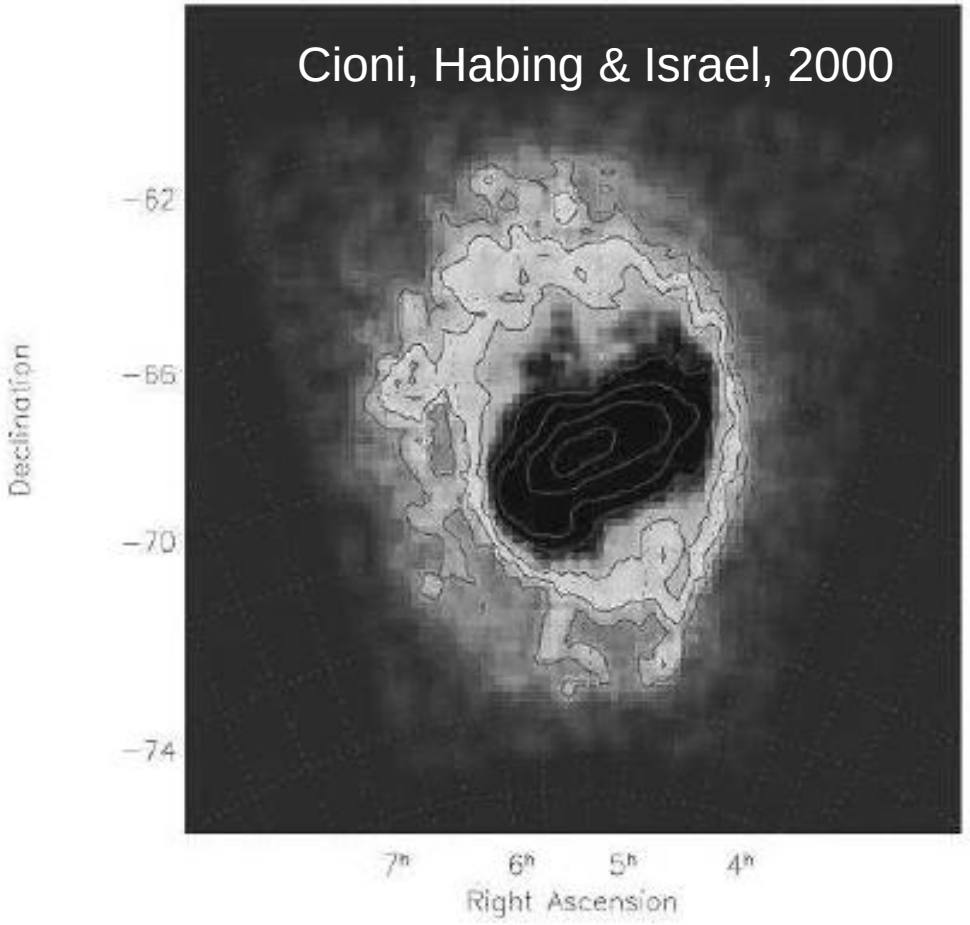
([X/H]=[X]-[X]$_\odot$),

21 PNe



Different types of populations in the Magellanic Clouds





Global parameters of the Galactic and Magellanic Cloud's planetary nebulae

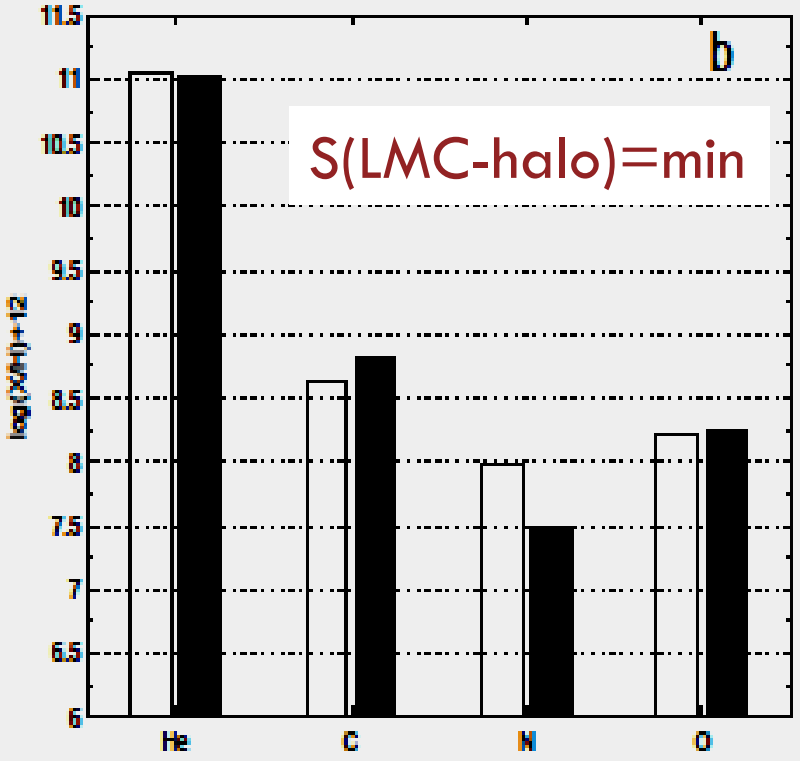
Peimbert's type	<z>	<M_{cs}>	[He]	[C]	[N]	[O]
I (thin disk)	0.23	0.69	11.21	8.32	8.96	8.63
IIa	0.31	0.64	11.13	8.82	8.73	8.75
IIb	0.56	0.62	11.03	8.55	8.36	8.53
III (thick disk)	1.05	0.60	10.94	8.60	7.92	8.41
IV (halo)	1.35	0.59	11.06	8.64	7.98	8.22
Bulge	0.56	0.61	11.16	8.74	8.59	8.86
LMC	-	0.65 (Villaver 2007)	11.02	8.80	7.49	8.24
SMC	-	0.65 (Villaver 2007)	11.10	8.98	8.08	8.30

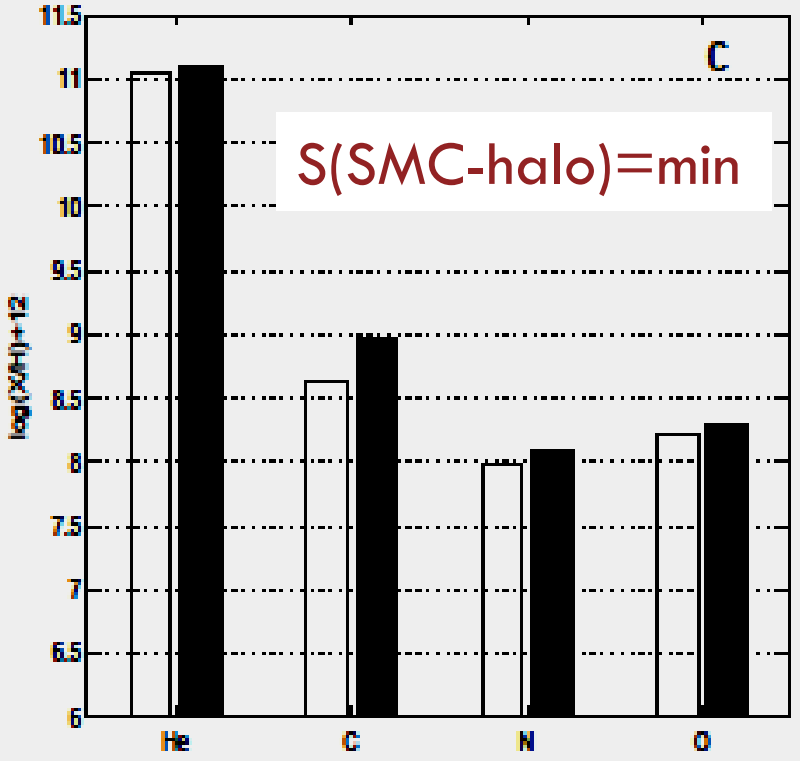
⊙ Asplund et.al. (2005)	10.93	8.39	7.78	8.66
⊙ Grevesse, Noels (1996)	10.99	8.55	7.97	8.87

Mean abundances for Magellanic Cloud's objects

	LMC			SMC	MW, halo		
	RG (Pompeia, 2008)	RRLyrae (Gratton, 2004)	PNe (present work)	PNe (present work)	F-G dwarves (Nissen, 1997)	C stars (Komiya, 2007)	PNe (present work)
[O/H]	-0.69 +/-0.39	-	-0.42 +/-0.55	-0.36 +/-0.21	-0.66 +/-0.21	-1.83 +/-0.83	-0.44 +/-0.36
[Mg/H]	-0.51 +/-0.22	-	-	-	-0.66 +/-0.19	-	-
[Si/H]	-0.67 +/-0.24	-	-	-	-0.71 +/-0.20	-	-
[Fe/H]	-0.75 +/-0.23	-1.49 +/-0.30	-	-	-0.87 +/-0.22	-2.99 +/-0.74	-

Comparison of the He, C, N, O abundances in Galactic halo and Magellanic Clouds



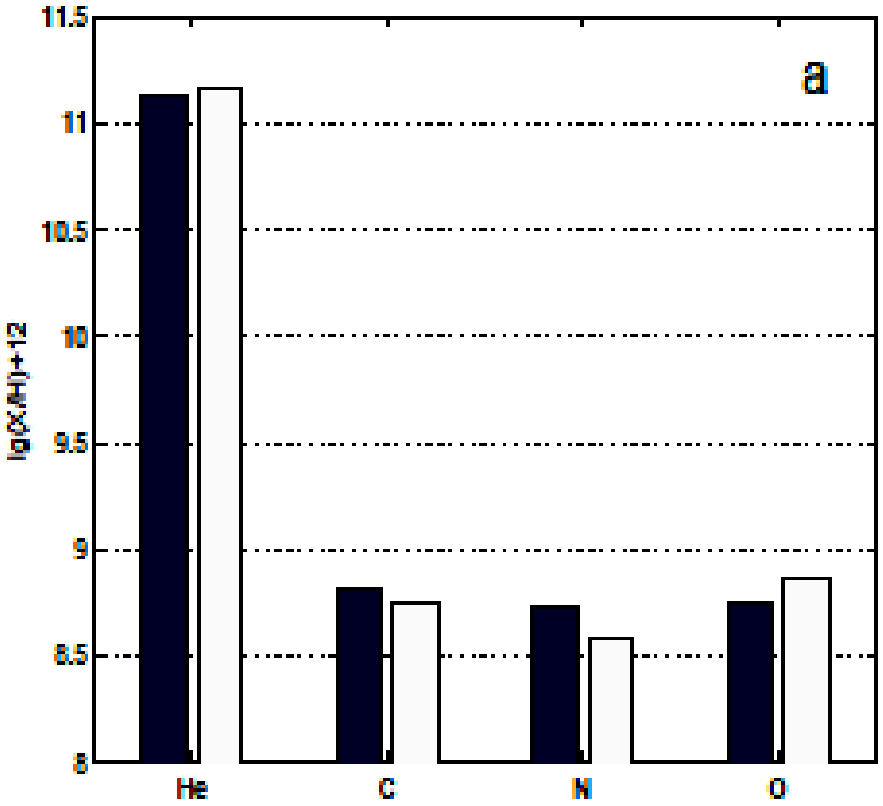


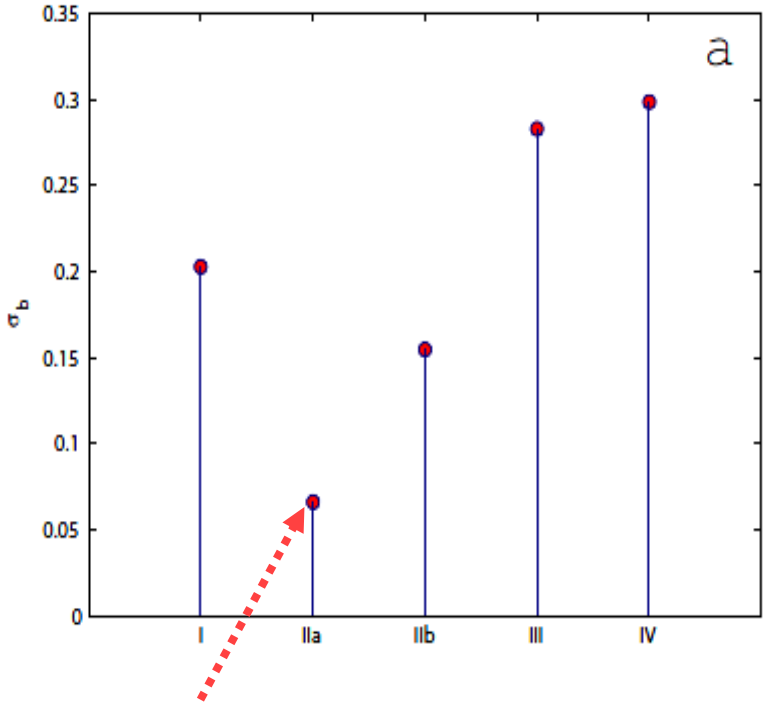
$$S(obj-type)=\sqrt{\sum_i([X_i^{obj}]-[X_i^{type}])^2},$$

$$X_i=\{[He],[C],[N],[O]\}$$

A nature of the PNe in the bulge

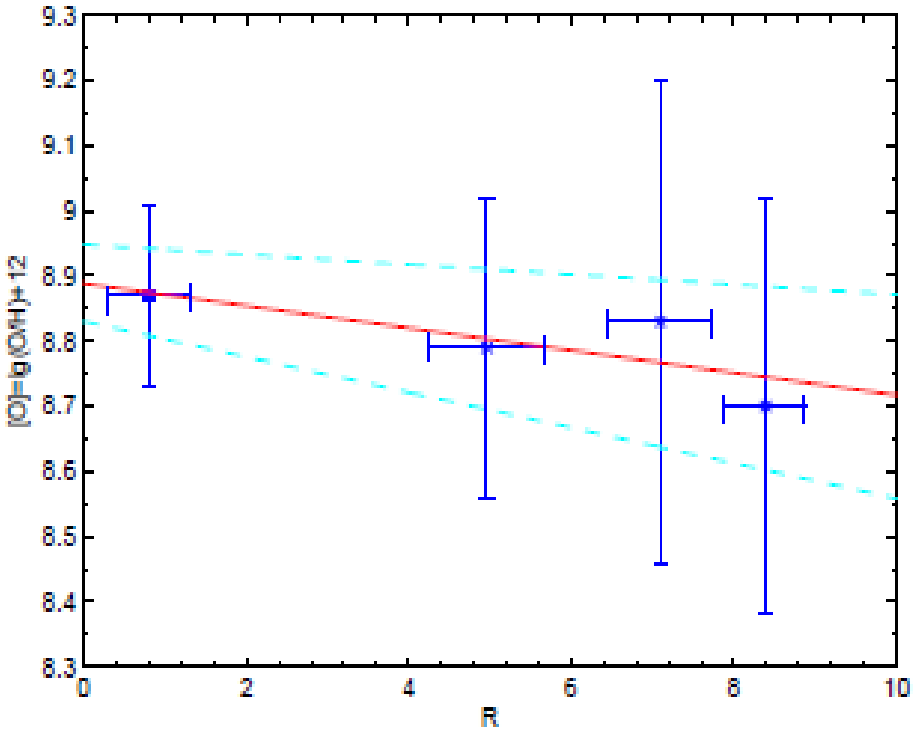
The He, C, N, O abundances in the Galactic thin disk and bulge



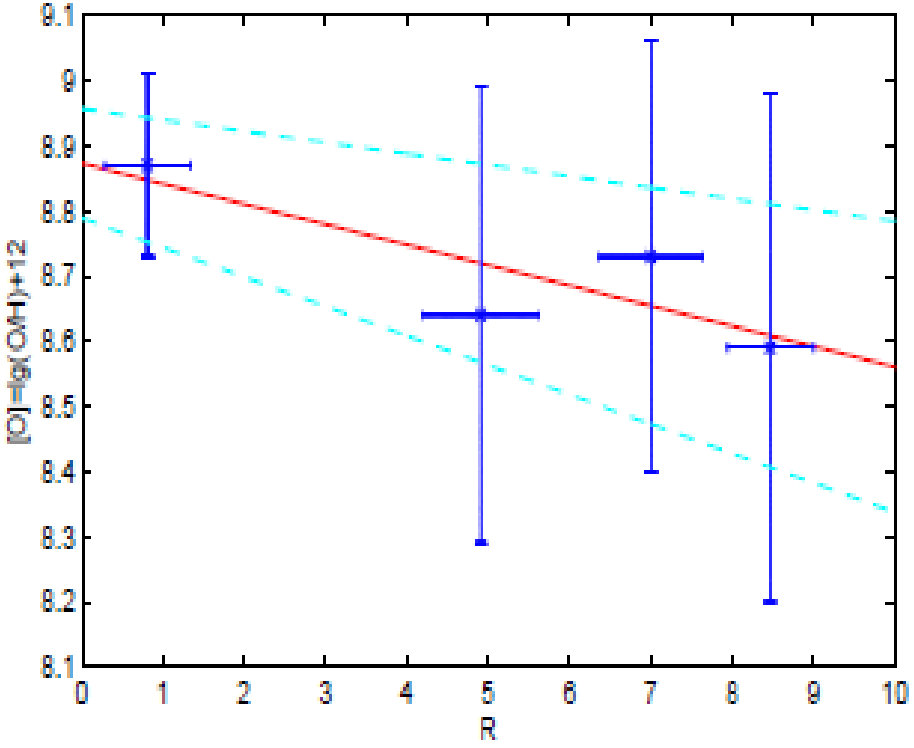


S(b-IIa)=min

Similarity of the bulge and disk PNe abundances



[O/H] vs. R for PNe of IIa type



[O/H] vs. R for PNe of II type

A scheme of the bulge and disk formation

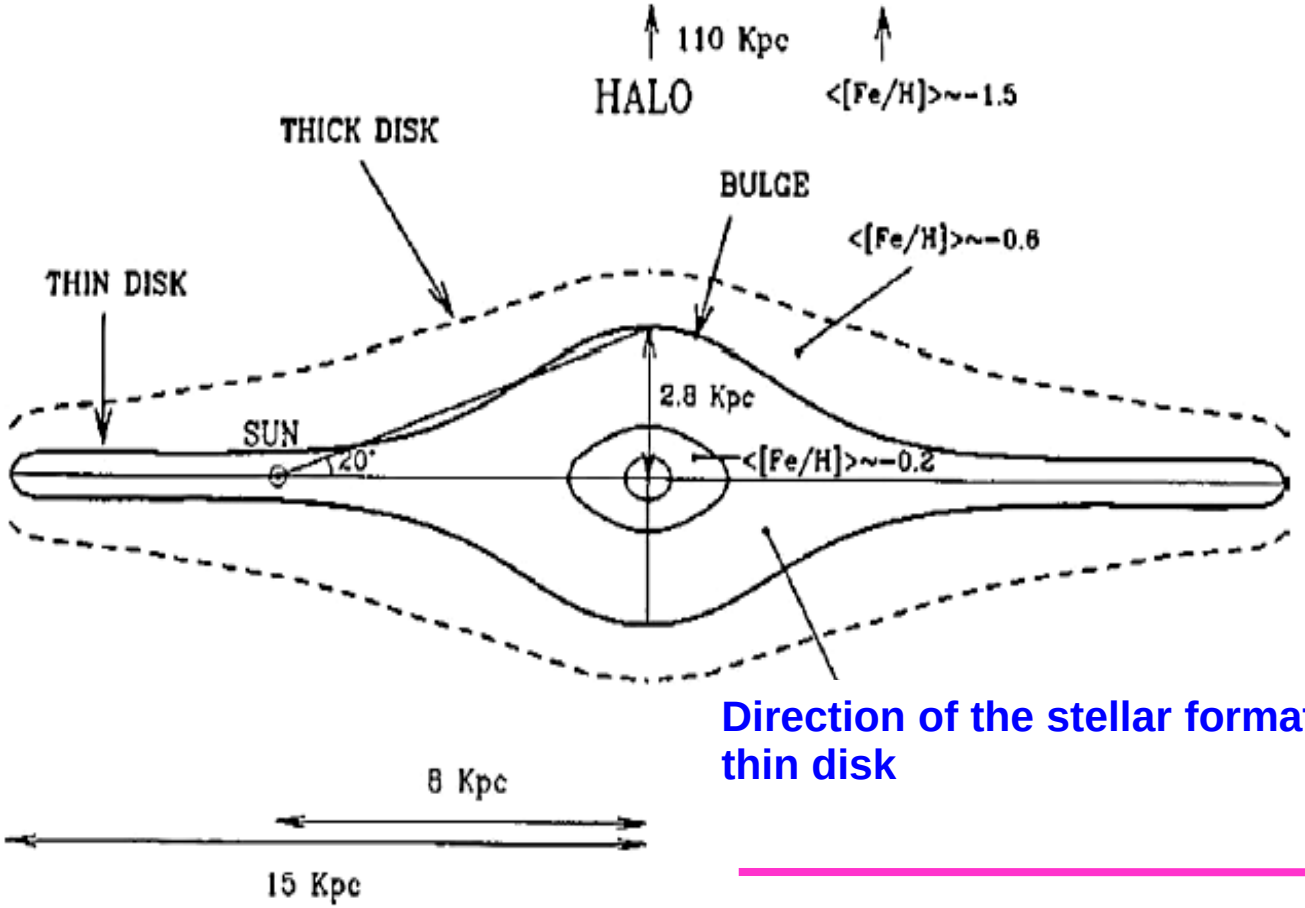


Fig. 1. Cross section of the vertical structure of the Milky Way (from Carraro, 2000). Stars with abundances identical to the Sun have [Fe/H] = 0.0; less metal rich stars have negative values and more metal rich stars have positive values.

Radial abundance gradients for disks of the spirals

Galaxy Name	d[O/H]/dR (dex/kpc)	d[Ne/H]/dR (dex/kpc)	Reference
M31	-0.03	-	*Garnett et al., 1997*
M33	-0.012+/-0.011	-0.016+/-0.017	*Crockett et al., 2006*
M51	-0.046	-	*Garnett et al., 1997*
M81	-0.08	-	*Garnett et al., 1987*
M101	-0.028+/-0.01	-	*Cedrés et al., 2004*
NGC 2403	-0.102+/-0.009	-	*Garnett et al., 1997*
Milky Way (all disk)	-0.012	-0.019	*Lunyova, Kholtygin, 2002* (our data)
Milky Way Disk (thin disk)	-0.031	-	Present work *Milanova, Kholtygin, 2009*

Conclusions

- The renormalization of the distances is made.
- New catalogue of PNe parameters is a good tool for study an evolution of the different galactic subsystems.
- The element abundance pattern for halo PNe and the nebulae in the Large and Small Magellanic Clouds are similar.
- The CNO and He abundances for the bulge and Peimbert's type IIa PNe are very close. The Oxygen abundances in the bulge PNe continue the dependence of [O/H] vs. R for PNe of type IIa.
- The bulge is formed on the early stage of the Galaxy evolution (in accordance with the Immeli (2004) scenario) after that the stellar formation begins in the disk starting from the regions close to bulge.