Magnetno polje u ostacima supernovih iz bliske zvezdorodne galasije M82

Branislav Vukotić
(istraživač-pripravnik)
AOB

bvukotic@aob.bg.ac.yu
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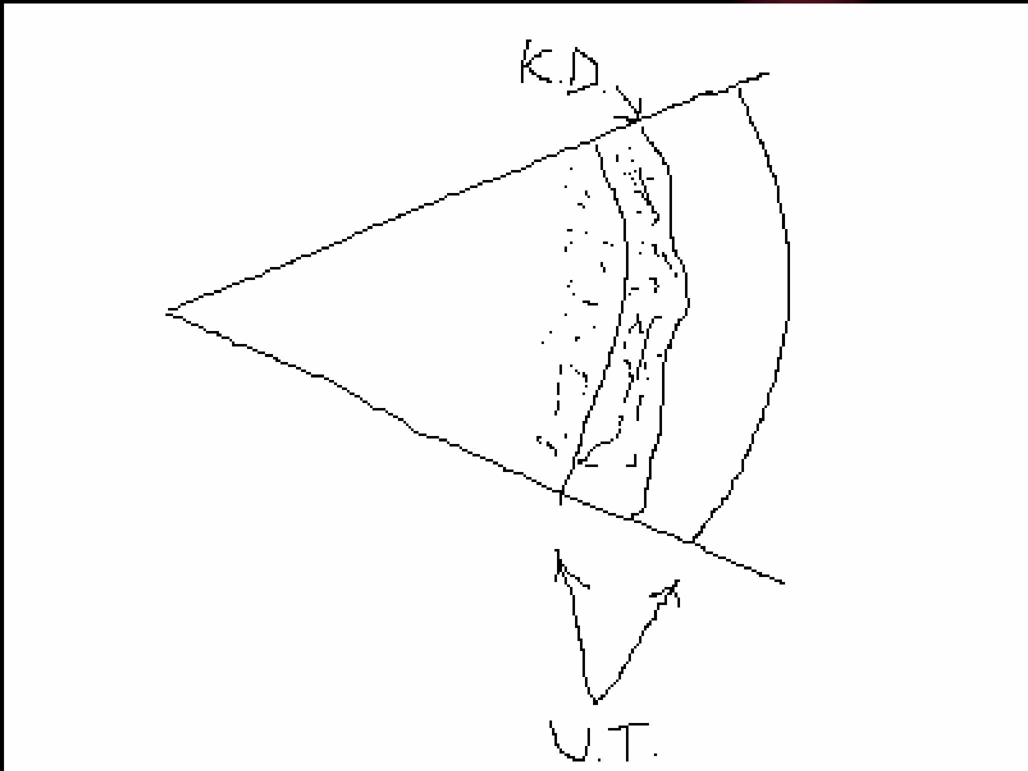
Magnetno polje u ostacima -- uopšteno

- Značaj: SNRs -> radio domen -> većinom netermalni, sinhrotronski, emiteri -> relativistički elektroni i magnetno polje
- Jačina: MZM -> ~ μG, SNR -> ~mG

Magnetno polje u ostacima -- uopšteno

- *Mehanizmi pojačanja: kompresija medjuzvezdanog polja, turbulentna amplifikacija, amplifikacija mhd talasima, Fermijev mehanizam*
- *Pravac: radijalno, tangentno i haotično*



M82 – zašto i kako?

- ***Najbolji uzorak u radio domenu -> najmanje izraženi selekcioni efekti (Huang et al. 1994, Urošević et al. 2005)***
- ***Ostaci evoluiraju u gustoj sredini ~10^3 cm^{-3}***
- ***Evolutivna faza?***

Računanje jačine magnetnog polja

- Postoji više načina. Podaci iz radio domena daju najbolji uzorak pa biramo način koji koristi samo merenja u radio domenu. Magnetno polje se računa iz gustine fluksa S_{ν} (mereno na minimum dve frekvencije) i dijametra D, ostatka.

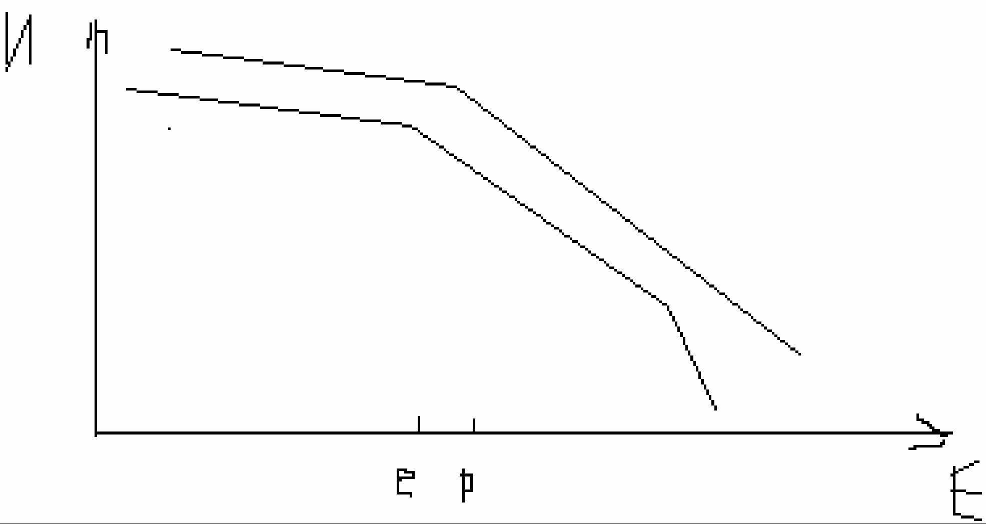
Energetski spektar CR

$$n(E)\,dE = n_0\,(E_b/E_0)^{(1-\gamma_0)/2}\,(E/E_0)^{-(\gamma_0+1)/2}\,dE$$

$$(E_1 < E < E_b)\,,$$

$$n(E)\,dE = n_0\,(E/E_0)^{-\gamma_0}\,dE$$

$$(E > E_b)$$



Revised equipartition calculation (Beck&Krause 2004)

$$L_\nu = 4\pi f V c_2(\gamma) n_{\mathrm{e},0} E_0^\gamma (\nu/2c_1)^{(1-\gamma)/2} H_\perp{}^{(\gamma+1)/2}. \quad (1)$$

$$c_2(\gamma) = \frac{1}{4} c_3 \frac{(\gamma + \frac{7}{3})}{\gamma + 1} \Gamma\left(\frac{3\gamma - 1}{12}\right) \times \Gamma\left(\frac{3\gamma + 7}{12}\right) \ \mathrm{erg}^{-2}\ \mathrm{s}^{-1}\ \mathrm{G}^{-1} \quad (2)$$

$$c_1 = 3e/(4\pi m_\mathrm{e}^3 c^5) = 6.26428 \cdot 10^{18}\ \mathrm{erg}^{-2}\ \mathrm{s}^{-1}\ \mathrm{G}^{-1} \quad (3)$$

$$c_3 = \frac{3^{\frac{1}{2}} e^3}{4\pi m_\mathrm{e} c^2} = 1.86558 \cdot 10^{-23}\ \mathrm{erg}\ \mathrm{G}^{-1}\ \mathrm{sterad}^{-1}\ \mathrm{G}^{-1} \quad (4)$$

$$\epsilon_p \cong \int_{E_1}^{E_\mathrm{p}} n_{\mathrm{p},0} \left(\frac{E_\mathrm{p}}{E_0}\right)^{-\gamma} E\ \mathrm{d}E + \int_{E_\mathrm{p}}^{E_2} n_{\mathrm{p},0} E_0 \left(\frac{E}{E_0}\right)^{1-\gamma} \mathrm{d}E \quad (5)$$

$$\epsilon_\mathrm{p} \cong n_{\mathrm{p},0} C(\gamma) \quad (6)$$

Revised equipartition calculation

$$C(\gamma) = E_0^2 \cdot \left\{ \frac{1}{2}\left(\frac{E_0}{E_\mathrm{p}}\right)^{\gamma-2} + \frac{1}{2-\gamma}\left[\left(\frac{E_0}{E_2}\right)^{\gamma-2} - \left(\frac{E_0}{E_\mathrm{p}}\right)^{\gamma-2}\right]\right\} \tag{7}$$

$$C(\gamma) = E_0^2\left[\frac{1}{2} + \ln\frac{E_2}{E_\mathrm{p}}\right] \tag{8}$$

$$\frac{\epsilon_\mathrm{p}}{\epsilon_\mathrm{e}} = K \tag{9}$$

$$\epsilon_\mathrm{CR} = (K+1)AH^{-\frac{\gamma+1}{2}} \tag{10}$$

$$A(\gamma, L_\nu, \nu) = \frac{L_\nu(\nu/2c_1)^{(\gamma-1)/2}}{4\pi c_2(\gamma)E_0{}^\gamma f V c_4(i)} \tag{11}$$

Revised equipartition calculation

$$c_4 = \left(\frac{2}{3}\right)^{\frac{\gamma+1}{4}} \tag{12}$$

$$\epsilon_{\rm tot} = \epsilon_{\rm CR} + \epsilon_{\rm H} \tag{13}$$

$$\epsilon_{\rm H} = \frac{H^2}{8\pi} \tag{14}$$

$$H_{\rm rev}^{\rm eqp} = [8\pi K A(\gamma, L_\nu, \nu) C(\gamma)]^{1/(\alpha+3)} \tag{15}$$

Rezultati

Name	D (pc)	$S_{1.4}$ (mJy)	α	$\Sigma_{1\,\mathrm{GHz}}$[a] $\left(\frac{\mathrm{W}}{\mathrm{m^2\ Hz\ sr}}\right)$	H^{eqp} (Ga)	$H^{\mathrm{eqp}}_{\mathrm{rev}}$ (Ga)
39.1+57.4	0.9	7.0	0.50	1.6E-15	5.91E-03	7.88E-03
39.4+56.1	3.23	3.5	0.58	6.1E-17	1.64E-03	1.87E-03
39.6+53.4	2.65	2.3	0.45	5.7E-17	1.70E-03	2.63E-03
40.6+56.1	3.02	3.9	0.72	8.3E-17	1.90E-03	2.05E-03
40.7+55.1	1.93	12.8	0.58	6.3E-16	3.70E-03	4.15E-03
41.3+59.6	1.02	5.2	0.52	9.0E-16	4.89E-03	6.11E-03
42.7+55.7	4.30	4.8	0.71	5.0E-17	1.48E-03	1.62E-03
42.8+61.3	1.97	2.9	0.63	1.4E-16	2.42E-03	2.63E-03
43.2+58.4	1.05	10.1	0.66	1.7E-15	5.99E-03	6.15E-03
43.3+59.2	0.60	23.5	0.68	1.2E-14	1.24E-03	1.21E-02
44.3+59.3	1.96	4.4	0.64	2.1E-16	2.75E-03	2.93E-03
44.5+58.2	2.25	3.0	0.50	1.1E-16	2.11E-03	2.82E-03
45.2+61.3	1.12	15.6	0.67	2.3E-15	6.44E-03	6.54E-03
45.3+65.2	2.05	4.4	0.82	2.1E-16	2.91E-03	3.06E-03
45.4+67.4	2.23	4.0	0.67	1.5E-16	2.42E-03	2.58E-03
45.8+65.3	2.13	3.2	0.46	1.3E-16	2.25E-03	3.42E-03
45.9+63.9	2.22	3.7	0.41	1.3E-16	2.27E-03	4.19E-03
46.5+63.9	1.39	5.4	0.74	5.4E-16	4.09E-03	4.20E-03
46.7+67.0	2.95	3.4	0.76	7.7E-17	1.90E-03	2.06E-03
41.9+58.0	0.52	120.4	0.75	8.6E-14	2.32E-02	2.12E-02
44.0+59.6	0.79	46.7	0.48	1.3E-14	1.13E-02	1.59E-02

Evolucija magnetnog polja

- $H{\sim}D^{-\delta}$
- Fitovanjem rezultata
- Zamenom L_{ν} – D korelacije (Arbutina et al. 2004) u jednacinu 15.

Rezultati

RESULTS FOR δ

Direct	
Shklovsky (1960) ($n_{e,0} \propto D^{-(2\alpha+3)}$)	0.125
Berezhko & Volk (2004) ($n_{e,0} \propto D^{-3}$)	0.875
Classical	
equipartition	1.26
Revised	
equipartition	1.22

Evolutivna faza?

- $\delta = 1.5 \approx 1.2 = \delta$ ***ostaci su u adijabatskoj fazi i ekviparticiji a razlika proizilazi iz selekcionih efekata (Urošević et al. 2005)***
- ***Octaci su u radijativnoj fazi (***$\delta = 1.25$***)- važi ekviparticija ali ne i adijab. aprox.(Chevalier & Fransson 2001)***
- ***Ekviparticija ne važi za sve ostatke- stariji ostaci sa H=const.*** $0 < \delta < 1.5$

KRAJ