Structural properties and reaction dynamics of some of the light highly neutron-rich Si, S and Ar isotopes

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The availability of radioactive ion beam (RIB) at intermediate energy range open up new opportunities to investigate some exotic phenomenon like neutron and proton halo, Borromean nuclei, neutron skin and bubble effect etc. The measurement of ^{40}Mg and ^{42}Al [1] beyond the dripline given by various mass formulae challenge the earlier predictions and still the investigation of dripline is an interesting topic in nuclear physics. Therefore, we investigate the structural properties and reaction dynamics of some of the isotopes of $^{32-35}$Si, $^{34-37}$S and $^{34-48}$Ar nuclei, which are well beyond the β- stability line. The bulk properties like binding energy (B.E.), charge radius (r_c) are calculated with well known relativistic mean field (RMF) [2] and newly developed non relativistic Hartree-Fock Formalism (HF) with simple effective interaction (SEI) [3]. The calculated values of B.E and r_c are listed in Table I along with experimental data, both showing nice agreement with each other. For reaction dynamics, we used the well known Glauber approach [4]. The reaction cross sections (σ_R) have been calculated by using expression

$$\sigma_R = 2\pi \int_0^\infty b[1 - T(b)]db, \qquad (1)$$

where 'T(b)' is the Transparency function with impact parameter 'b'. The main ingredient of Glauber model are the densities of projectile and target nuclei. The densities are taken from RMF(NL3) and HF(SEI). The densities of chosen set of nuclei are plotted as a radial distance in Fig.1 using both formalism.

The spherical densities of projectile and target are converted into the Gaussian form in terms of their coefficient c_i's and a_i's. These coefficients are listed in Table II. Other ingredients for reaction cross sections are some energy dependent parameters σ_{NN} , α_{NN} and β_{NN}, which are estimated using Ref. [7]. Figure 2 shows the variation of σ_R as a function of projectile energy (E_{proj}), for RMF(NL3) and HF(SEI) densities. The σ_R show large magnitude at lower E_{proj}, which start decreasing upto 300 MeV/nucleon. Small enhancement in σ_R is observed upto 300-750 MeV/nucleon and after that, it remains constant. From Fig. 2, we observed that the σ_R values obtained from the HF(SEI) densities are slightly higher

TABLE I: The calculated values of binding energy (B.E.) in MeV and charge radius (r_c) in fm for projectile and target nuclei from RMF(NL3) and HF(SEI) along with experimental data [5, 6].

Nuclei	B.E			r_c		
	HF SEI	RMF NL3	Expt. .	HF SEI	RMF NL3	Expt
^{12}C	88.422	88.23	92.160	2.436	2.364	2.47
^{32}Si	267.928	267.69	271.407	3.095	3.113	
^{33}Si	275.953	275.97	275.915	3.095	3.133	
^{34}Si	283.470	283.78	283.428	3.111	3.153	
^{35}Si	288.258	289.77	285.903	3.119	3.163	
^{34}S	286.424	286.05	291.838	3.199	3.270	3.28
^{35}S	296.491	296.71	298.824	3.209	3.282	
^{36}S	305.978	306.52	308.714	3.219	3.293	3.29
^{37}S	312.676	313.58	313.017	3.224	3.299	
^{34}Ar	273.357	273.76	278.719	3.295	3.387	3.365
^{36}Ar	300.129	300.25	306.716	3.305	3.388	3.390
^{38}Ar	324.432	325.59	327.342	3.318	3.397	3.402
^{40}Ar	341.555	342.31	343.810	3.326	3.401	3.427
^{42}Ar	357.013	357.39	359.335	3.335	3.406	3.435
^{44}Ar	371.135	371.42	373.728	3.345	3.410	3.445
^{46}Ar	383.672	384.57	386.927	3.373	3.410	3.437
^{48}Ar	391.79	394.58	396	3.393	3.437	

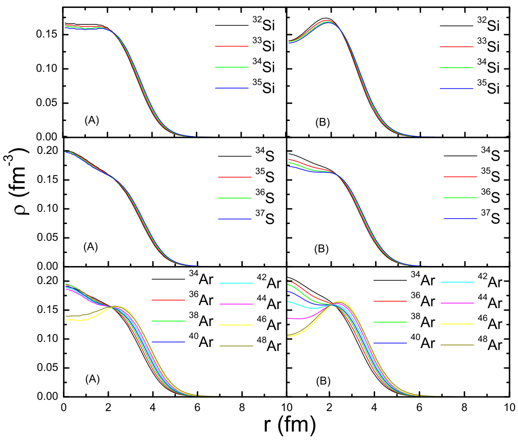

FIG. 1: Radial density plots for $^{32-35}$Si, $^{34-37}$S and $^{34-48}$Ar nuclei for (A) HF(SEI) and (B) RMF(NL3).

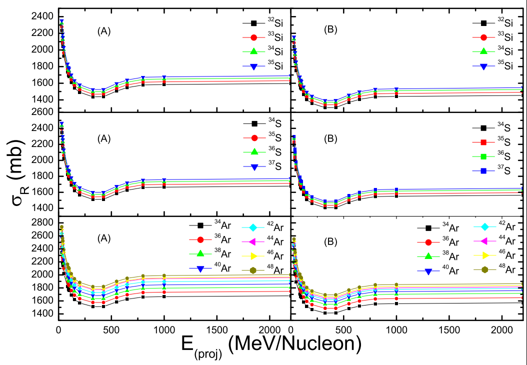

FIG. 2: Variation of total reaction cross section as function of projectile energy using (A) HF(SEI) and (B) RMF(NL3).

than one obtained using RMF(NL3) densities.

TABLE II: The Gaussian coefficients c_1, a_1, c_2, a_2 of projectile and target nuclei for RMF(NL3) and HF(SEI) densities.

Nuclei		c_1	a_1	c_2	a_2
^{12}C	HF(SEI)	-3.79616	0.361674	3.98071	0.345423
	RMF	-0.232654	0.638687	0.0.517232	0.339911
^{32}Si	HF(SEI)	-2.37277	0.202381	2.51805	0.184376
	RMF	-3.00897	0.227291	3.13661	0.206144
^{33}Si	HF(SEI)	-2.35386	0.196639	2.49616	0.179151
	RMF	-2.9272	0.218848	3.05298	0.198521
^{34}Si	HF(SEI)	-2.34203	0.191388	2.48123	0.174374
	RMF	-2.86769	0.211811	2.99191	0.192149
^{35}Si	HF(SEI)	-2.36933	0.187986	2.50617	0.171288
	RMF	-2.88628	0.208281	3.00941	0.188926
^{34}S	HF(SEI)	-1.81296	0.181829	1.98726	0.165612
	RMF	-2.03669	0.193789	2.20712	0.175664
^{35}S	HF(SEI)	-1.78947	0.176802	1.96139	0.161028
	RMF	-2.11099	0.189798	2.27085	0.172077
^{36}S	HF(SEI)	-1.76837	0.172069	1.93796	0.156714
	RMF	-2.13714	0.185085	2.28947	0.167819
^{37}S	HF(SEI)	-1.79518	0.169348	1.96303	0.154256
	RMF	-2.21565	0.183299	2.3634	0.166219
^{34}Ar	HF(SEI)	-1.93044	0.183573	2.09551	0.167211
	RMF	-1.84812	0.18999	2.02988	0.172144
^{36}Ar	HF(SEI)	-1.83132	0.172884	1.99595	0.157479
	RMF	-1.79242	0.177609	1.96319	0.160928
^{38}Ar	HF(SEI)	-1.79848	0.164912	1.96024	0.150194
	RMF	-1.82537	0.169399	1.98489	0.153507
^{40}Ar	HF(SEI)	-1.85865	0.160185	2.01657	0.145936
	RMF	-1.99749	0.166945	2.14665	0.151332
^{42}Ar	HF(SEI)	-1.91109	0.155909	2.06565	0.142049
	RMF	-2.26358	0.166337	2.39771	0.150869
^{44}Ar	HF(SEI)	-1.96876	0.151999	2.11994	0.138517
	RMF	-2.68801	0.168372	2.79633	0.152825
^{46}Ar	HF(SEI)	-2.71167	0.158333	2.8162	0.144599
	RMF	-3.13997	0.170354	3.22018	0.154714
^{48}Ar	HF(SEI)	-2.68582	0.155294	2.80113	0.141718
	RMF	-3.15705	0.167492	3.24426	0.152135

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