$^{4}\textbf{He}(^{36}\textbf{Ar},\alpha)\textbf{:resonances}$ **2011No12**

2011No12: E=150 MeV ^{36}Ar beam was produced from the K-130 cyclotron at the university of Jyvaskyla, Finland and entered scattering chamber of helium gas through Havar foil. Recoiling α-particles were detected by rotating array of four silicon surface detectors (FWHM=30 keV), each separated by 6° and mounted on a turntable, together with another (monitor) detector which was fixed at −15°. Measured Eα, cross section, $\sigma(\theta)$. Deduced excitation function, levels, and widths. R-matrix analysis of excitation function data. Discussed α-cluster structure in the quasi-continuum of ^{40}Ca.

^{40}Ca Levels

$\gamma^2_\alpha/\gamma^2_{sp}$=relative reduced widths. Uncertainty on these values is large and probably overestimated by 30%.

Γ_α/Γ>1.00 values listed here are non-physical. The authors point out that thorough analysis of background contributions may correct the problem.

All resonance parameters are extracted from R-matrix fits to excitation functions and the values are approximate according to the authors. Cross sections have maximum uncertainty of 20%.

E(level)[†]	Γ	L	Comments
12420	<0.05 MeV	1	Γ_α/Γ=0.80; $\gamma^2_\alpha/\gamma^2_{sp}$=79.8%.
12530	<0.03 MeV	1	Γ_α/Γ=0.60; $\gamma^2_\alpha/\gamma^2_{sp}$=29.6%.
12580	<0.03 MeV	1	Γ_α/Γ=0.70; $\gamma^2_\alpha/\gamma^2_{sp}$=30.9%.
12670	<0.05 MeV	1	Γ_α/Γ=1.00; $\gamma^2_\alpha/\gamma^2_{sp}$=63.5%.
12740	<0.03 MeV	2	Γ_α/Γ=0.40; $\gamma^2_\alpha/\gamma^2_{sp}$=23.9%.
12795	<0.04 MeV	1	Γ_α/Γ=0.60; $\gamma^2_\alpha/\gamma^2_{sp}$=24.8%.
12835	<0.03 MeV	2	Γ_α/Γ=0.70; $\gamma^2_\alpha/\gamma^2_{sp}$=36.7%.
12900	<0.04 MeV	2	Γ_α/Γ=0.35; $\gamma^2_\alpha/\gamma^2_{sp}$=21.7%.
12965	<0.04 MeV	2	Γ_α/Γ=0.80; $\gamma^2_\alpha/\gamma^2_{sp}$=44.7%.
13050	<0.04 MeV	2	Γ_α/Γ=0.90; $\gamma^2_\alpha/\gamma^2_{sp}$=41.9%.
13125	<0.04 MeV	2	Γ_α/Γ=1.00; $\gamma^2_\alpha/\gamma^2_{sp}$=43.0%.
13170	<0.02 MeV	3	Γ_α/Γ=0.80; $\gamma^2_\alpha/\gamma^2_{sp}$=34.4%.
13245	<0.04 MeV	2	Γ_α/Γ=0.80; $\gamma^2_\alpha/\gamma^2_{sp}$=28.8%.
13301	<0.04 MeV	2	Γ_α/Γ=1.00; $\gamma^2_\alpha/\gamma^2_{sp}$=28.8%.
13345	<0.03 MeV	3	Γ_α/Γ=1.10; $\gamma^2_\alpha/\gamma^2_{sp}$=54.2%.
13410	<0.04 MeV	3	Γ_α/Γ=0.85; $\gamma^2_\alpha/\gamma^2_{sp}$=50.0%.
13480	<0.03 MeV	3	Γ_α/Γ=0.20; $\gamma^2_\alpha/\gamma^2_{sp}$=8.4%.
13520	<0.04 MeV	3	Γ_α/Γ=0.30; $\gamma^2_\alpha/\gamma^2_{sp}$=15.2%.
13570	<0.05 MeV	3	Γ_α/Γ=0.35; $\gamma^2_\alpha/\gamma^2_{sp}$=20.4%.
13620	<0.04 MeV	3	Γ_α/Γ=0.38; $\gamma^2_\alpha/\gamma^2_{sp}$=17.0%.
13645	<0.04 MeV	3	Γ_α/Γ=0.20; $\gamma^2_\alpha/\gamma^2_{sp}$=8.6%.
13710	<0.03 MeV	3	Γ_α/Γ=0.63; $\gamma^2_\alpha/\gamma^2_{sp}$=18.9%.
13760	<0.04 MeV	3	Γ_α/Γ=0.30; $\gamma^2_\alpha/\gamma^2_{sp}$=10.8%.
13850	<0.03 MeV	3	Γ_α/Γ=0.75; $\gamma^2_\alpha/\gamma^2_{sp}$=18.5%.
13910	<0.02 MeV	3	Γ_α/Γ=0.90; $\gamma^2_\alpha/\gamma^2_{sp}$=13.6%.
13960	<0.02 MeV	3	Γ_α/Γ=0.70; $\gamma^2_\alpha/\gamma^2_{sp}$=10.0%.
14005	<0.02 MeV	3	Γ_α/Γ=0.73; $\gamma^2_\alpha/\gamma^2_{sp}$=10.0%.
14047	<0.02 MeV	3	Γ_α/Γ=0.83; $\gamma^2_\alpha/\gamma^2_{sp}$=10.8%.
14150	<0.03 MeV	3	Γ_α/Γ=0.55; $\gamma^2_\alpha/\gamma^2_{sp}$=9.4%.
14177	<0.03 MeV	3	Γ_α/Γ=0.60; $\gamma^2_\alpha/\gamma^2_{sp}$=10.1%.
14225	<0.02 MeV	3	Γ_α/Γ=0.60; $\gamma^2_\alpha/\gamma^2_{sp}$=6.3%.
14262	<0.02 MeV	3	Γ_α/Γ=0.60; $\gamma^2_\alpha/\gamma^2_{sp}$=6.0%.
14292	<0.02 MeV	3	Γ_α/Γ=0.45; $\gamma^2_\alpha/\gamma^2_{sp}$=4.3%.

$^4\text{He}(^{36}\text{Ar},\alpha)$:resonances   2011No12 (continued)

^{40}Ca Levels (continued)

E(level)[†]	Γ	L	Comments
14312	<0.02 MeV	3	Γ_α/Γ=0.42; $\gamma_\alpha^2/\gamma_{sp}^2$=4.0%.
14335	<0.02 MeV	3	Γ_α/Γ=0.50; $\gamma_\alpha^2/\gamma_{sp}^2$=4.7%.
14390	<0.03 MeV	3	Γ_α/Γ=0.90; $\gamma_\alpha^2/\gamma_{sp}^2$=11.8%.
14435	<0.03 MeV	3	Γ_α/Γ=0.95; $\gamma_\alpha^2/\gamma_{sp}^2$=11.9%.
14490	<0.04 MeV	3	Γ_α/Γ=0.50; $\gamma_\alpha^2/\gamma_{sp}^2$=7.9%.
14540	<0.03 MeV	3	Γ_α/Γ=1.00; $\gamma_\alpha^2/\gamma_{sp}^2$=11.3%.
14605	<0.04 MeV	3	Γ_α/Γ=1.00; $\gamma_\alpha^2/\gamma_{sp}^2$=14.1%.
14640	<0.03 MeV	3	Γ_α/Γ=0.70; $\gamma_\alpha^2/\gamma_{sp}^2$=7.2%.
14690	<0.03 MeV	3	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=2.9%.
14725	<0.05 MeV	3	Γ_α/Γ=1.30; $\gamma_\alpha^2/\gamma_{sp}^2$=20.6%.
14760	<0.03 MeV	3	Γ_α/Γ=0.70; $\gamma_\alpha^2/\gamma_{sp}^2$=6.4%.
14790	<0.03 MeV	3	Γ_α/Γ=0.65; $\gamma_\alpha^2/\gamma_{sp}^2$=5.8%.
14835	<0.03 MeV	3	Γ_α/Γ=1.20; $\gamma_\alpha^2/\gamma_{sp}^2$=10.4%.
14888	<0.04 MeV	3	Γ_α/Γ=1.55; $\gamma_\alpha^2/\gamma_{sp}^2$=13.8%.
14942	<0.03 MeV	3	Γ_α/Γ=1.40; $\gamma_\alpha^2/\gamma_{sp}^2$=10.7%.
15002	<0.04 MeV	3	Γ_α/Γ=1.15; $\gamma_\alpha^2/\gamma_{sp}^2$=11.7%.
15052	<0.03 MeV	3	Γ_α/Γ=1.45; $\gamma_\alpha^2/\gamma_{sp}^2$=10.1%.
15101	<0.03 MeV	3	Γ_α/Γ=1.70; $\gamma_\alpha^2/\gamma_{sp}^2$=11.9%.
15150	<0.04 MeV	3	Γ_α/Γ=0.80; $\gamma_\alpha^2/\gamma_{sp}^2$=6.9%.
15220	<0.03 MeV	3	Γ_α/Γ=0.60; $\gamma_\alpha^2/\gamma_{sp}^2$=3.9%.
15260	<0.03 MeV	3	Γ_α/Γ=0.65; $\gamma_\alpha^2/\gamma_{sp}^2$=3.9%.
15285	<0.05 MeV	4	Γ_α/Γ=0.80; $\gamma_\alpha^2/\gamma_{sp}^2$=16.2%.
15345	<0.04 MeV	4	Γ_α/Γ=0.60; $\gamma_\alpha^2/\gamma_{sp}^2$=9.2%.
15384	<0.04 MeV	4	Γ_α/Γ=0.78; $\gamma_\alpha^2/\gamma_{sp}^2$=11.5%.
15435	<0.04 MeV	4	Γ_α/Γ=0.87; $\gamma_\alpha^2/\gamma_{sp}^2$=12.3%.
15490	<0.04 MeV	4	Γ_α/Γ=0.85; $\gamma_\alpha^2/\gamma_{sp}^2$=11.4%.
15525	<0.02 MeV	4	Γ_α/Γ=0.20; $\gamma_\alpha^2/\gamma_{sp}^2$=1.3%.
15550	<0.03 MeV	4	Γ_α/Γ=0.70; $\gamma_\alpha^2/\gamma_{sp}^2$=6.7%.
15580	<0.03 MeV	4	Γ_α/Γ=0.56; $\gamma_\alpha^2/\gamma_{sp}^2$=5.2%.
15620	<0.03 MeV	4	Γ_α/Γ=1.05; $\gamma_\alpha^2/\gamma_{sp}^2$=9.6%.
15670	<0.02 MeV	4	Γ_α/Γ=1.00; $\gamma_\alpha^2/\gamma_{sp}^2$=5.8%.
15707	<0.03 MeV	4	Γ_α/Γ=0.45; $\gamma_\alpha^2/\gamma_{sp}^2$=3.8%.
15790	<0.04 MeV	4	Γ_α/Γ=1.00; $\gamma_\alpha^2/\gamma_{sp}^2$=10.2%.
15840	<0.03 MeV	4	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=2.3%.
15875	<0.02 MeV	4	Γ_α/Γ=0.93; $\gamma_\alpha^2/\gamma_{sp}^2$=4.7%.
15915	<0.02 MeV	4	Γ_α/Γ=0.98; $\gamma_\alpha^2/\gamma_{sp}^2$=4.6%.
15950	<0.02 MeV	5	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=3.4%.
15960	<0.02 MeV	4	Γ_α/Γ=0.97; $\gamma_\alpha^2/\gamma_{sp}^2$=4.5%.
16000	<0.02 MeV	5	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=3.2%.
16020	<0.03 MeV	4	Γ_α/Γ=0.41; $\gamma_\alpha^2/\gamma_{sp}^2$=2.6%.
16065	<0.03 MeV	4	Γ_α/Γ=0.45; $\gamma_\alpha^2/\gamma_{sp}^2$=2.9%.
16110	<0.02 MeV	5	Γ_α/Γ=0.10; $\gamma_\alpha^2/\gamma_{sp}^2$=1.0%.
16120	<0.03 MeV	4	Γ_α/Γ=0.42; $\gamma_\alpha^2/\gamma_{sp}^2$=2.7%.
16160	<0.03 MeV	4	Γ_α/Γ=0.41; $\gamma_\alpha^2/\gamma_{sp}^2$=2.4%.
16210	<0.03 MeV	4	Γ_α/Γ=0.37; $\gamma_\alpha^2/\gamma_{sp}^2$=2.2%.
16255	<0.02 MeV	4	Γ_α/Γ=0.48; $\gamma_\alpha^2/\gamma_{sp}^2$=1.8%.
16290	<0.02 MeV	4	Γ_α/Γ=0.36; $\gamma_\alpha^2/\gamma_{sp}^2$=1.3%.
16360	<0.02 MeV	4	Γ_α/Γ=0.25; $\gamma_\alpha^2/\gamma_{sp}^2$=0.9%.
16395	<0.02 MeV	4	Γ_α/Γ=0.45; $\gamma_\alpha^2/\gamma_{sp}^2$=1.6%.
16450	<0.02 MeV	4	Γ_α/Γ=0.37; $\gamma_\alpha^2/\gamma_{sp}^2$=1.2%.
16510	<0.02 MeV	4	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=1.0%.

^{4}He(^{36}Ar,α):resonances   2011No12 (continued)

^{40}Ca Levels (continued)

E(level)[†]	Γ	L	Comments
16545	<0.02 MeV	5	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=2.0%.
16585	<0.02 MeV	5	Γ_α/Γ=0.20; $\gamma_\alpha^2/\gamma_{sp}^2$=1.3%.
16610	<0.02 MeV	6	Γ_α/Γ=0.10; $\gamma_\alpha^2/\gamma_{sp}^2$=1.8%.
16640	<0.02 MeV	5	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=1.9%.
16665	<0.02 MeV	6	Γ_α/Γ=0.38; $\gamma_\alpha^2/\gamma_{sp}^2$=6.6%.
16735	<0.02 MeV	6	Γ_α/Γ=0.38; $\gamma_\alpha^2/\gamma_{sp}^2$=6.2%.
16810	<0.02 MeV	6	Γ_α/Γ=0.33; $\gamma_\alpha^2/\gamma_{sp}^2$=5.0%.
16910	<0.05 MeV	6	Γ_α/Γ=0.33; $\gamma_\alpha^2/\gamma_{sp}^2$=11.5%.
16945	<0.02 MeV	6	Γ_α/Γ=0.12; $\gamma_\alpha^2/\gamma_{sp}^2$=1.6%.
17010	<0.03 MeV	6	Γ_α/Γ=0.40; $\gamma_\alpha^2/\gamma_{sp}^2$=6.4%.
17065	<0.02 MeV	6	Γ_α/Γ=0.38; $\gamma_\alpha^2/\gamma_{sp}^2$=4.7%.
17113	<0.02 MeV	6	Γ_α/Γ=0.60; $\gamma_\alpha^2/\gamma_{sp}^2$=7.1%.
17170	<0.02 MeV	6	Γ_α/Γ=0.33; $\gamma_\alpha^2/\gamma_{sp}^2$=3.7%.
17210	<0.03 MeV	6	Γ_α/Γ=0.40; $\gamma_\alpha^2/\gamma_{sp}^2$=6.6%.
17280	<0.03 MeV	6	Γ_α/Γ=0.33; $\gamma_\alpha^2/\gamma_{sp}^2$=5.1%.
17320	<0.02 MeV	6	Γ_α/Γ=0.10; $\gamma_\alpha^2/\gamma_{sp}^2$=1%.
17360	<0.03 MeV	6	Γ_α/Γ=0.25; $\gamma_\alpha^2/\gamma_{sp}^2$=3.6%.
17410	<0.03 MeV	6	Γ_α/Γ=0.35; $\gamma_\alpha^2/\gamma_{sp}^2$=4.9%.
17450	<0.03 MeV	6	Γ_α/Γ=0.33; $\gamma_\alpha^2/\gamma_{sp}^2$=4.5%.
17513	<0.05 MeV	6	Γ_α/Γ=0.35; $\gamma_\alpha^2/\gamma_{sp}^2$=7.6%.
17590	<0.05 MeV	6	Γ_α/Γ=0.20; $\gamma_\alpha^2/\gamma_{sp}^2$=4.1%.
17670	<0.05 MeV	6	Γ_α/Γ=0.37; $\gamma_\alpha^2/\gamma_{sp}^2$=7.2%.
17730	<0.03 MeV	6	Γ_α/Γ=0.55; $\gamma_\alpha^2/\gamma_{sp}^2$=6.1%.
17790	<0.03 MeV	6	Γ_α/Γ=0.36; $\gamma_\alpha^2/\gamma_{sp}^2$=3.8%.
17855	<0.04 MeV	6	Γ_α/Γ=0.28; $\gamma_\alpha^2/\gamma_{sp}^2$=3.8%.
17915	<0.02 MeV	6	Γ_α/Γ=0.42; $\gamma_\alpha^2/\gamma_{sp}^2$=2.8%.
17950	<0.02 MeV	6	Γ_α/Γ=0.50; $\gamma_\alpha^2/\gamma_{sp}^2$=3.2%.
18010	<0.02 MeV	6	Γ_α/Γ=0.55; $\gamma_\alpha^2/\gamma_{sp}^2$=3.4%.
18077	<0.05 MeV	6	Γ_α/Γ=0.27; $\gamma_\alpha^2/\gamma_{sp}^2$=4.0%.
18139	<0.03 MeV	6	Γ_α/Γ=0.40; $\gamma_\alpha^2/\gamma_{sp}^2$=3.4%.
18174	<0.03 MeV	6	Γ_α/Γ=0.43; $\gamma_\alpha^2/\gamma_{sp}^2$=3.6%.
18260	<0.05 MeV	6	Γ_α/Γ=0.15; $\gamma_\alpha^2/\gamma_{sp}^2$=1.9%.
18328	<0.05 MeV	6	Γ_α/Γ=0.40; $\gamma_\alpha^2/\gamma_{sp}^2$=5.1%.
18406	<0.03 MeV	6	Γ_α/Γ=0.28; $\gamma_\alpha^2/\gamma_{sp}^2$=2.0%.
18485	<0.02 MeV	6	Γ_α/Γ=0.87; $\gamma_\alpha^2/\gamma_{sp}^2$=4.1%.
18547	<0.03 MeV	6	Γ_α/Γ=0.35; $\gamma_\alpha^2/\gamma_{sp}^2$=2.3%.
18605	<0.04 MeV	6	Γ_α/Γ=0.28; $\gamma_\alpha^2/\gamma_{sp}^2$=2.4%.
18659	<0.02 MeV	6	Γ_α/Γ=0.38; $\gamma_\alpha^2/\gamma_{sp}^2$=1.6%.
18705	<0.02 MeV	6	Γ_α/Γ=0.27; $\gamma_\alpha^2/\gamma_{sp}^2$=1.1%.
18765	<0.04 MeV	5	Γ_α/Γ=0.48; $\gamma_\alpha^2/\gamma_{sp}^2$=3.8%.
18865	<0.03 MeV	6	Γ_α/Γ=0.45; $\gamma_\alpha^2/\gamma_{sp}^2$=2.5%.
18930	<0.02 MeV	6	Γ_α/Γ=0.52; $\gamma_\alpha^2/\gamma_{sp}^2$=1.8%.
19020	<0.03 MeV	6	Γ_α/Γ=0.25; $\gamma_\alpha^2/\gamma_{sp}^2$=1.3%.
19080	<0.05 MeV	6	Γ_α/Γ=0.18; $\gamma_\alpha^2/\gamma_{sp}^2$=1.5%.
19150	<0.07 MeV	6	Γ_α/Γ=0.40; $\gamma_\alpha^2/\gamma_{sp}^2$=4.6%.
19230	<0.03 MeV	6	Γ_α/Γ=0.30; $\gamma_\alpha^2/\gamma_{sp}^2$=1.4%.
19280	<0.03 MeV	6	Γ_α/Γ=0.73; $\gamma_\alpha^2/\gamma_{sp}^2$=3.4%.
19385	<0.03 MeV	6	Γ_α/Γ=0.46; $\gamma_\alpha^2/\gamma_{sp}^2$=2.0%.
19467	<0.04 MeV	6	Γ_α/Γ=0.34; $\gamma_\alpha^2/\gamma_{sp}^2$=1.9%.
19525	<0.02 MeV	6	Γ_α/Γ=0.22; $\gamma_\alpha^2/\gamma_{sp}^2$=0.6%.
19597	<0.02 MeV	6	Γ_α/Γ=0.80; $\gamma_\alpha^2/\gamma_{sp}^2$=2.1%.

$\underline{^{40}\text{Ca Levels (continued)}}$

E(level)[†]	Γ	L	Comments
19667	<0.04 MeV	6	Γ_α/Γ=0.20; $\gamma^2_\alpha/\gamma^2_{sp}$=1.0%.
19780	<0.06 MeV	6	Γ_α/Γ=0.28; $\gamma^2_\alpha/\gamma^2_{sp}$=2.1%.

[†] Estimated maximum uncertainty in absolute energy=150 keV.