Was an α emitter present in the fuel in the March 2014 test of the E-Cat?

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Three figures in an appendix to the report by Levi *et al.* show spectra with mass peaks for ions with masses at $m \geq 100$. Although some of the ions were no doubt cluster ions, heavier elements might also have been present. We examine two of the figures for possible elements and derive approximate upper bounds on the counts relative to the other peaks in the figures. Ranges of mass peaks are consistent with small amounts of samarium, rhenium, hafnium and other elements. Many of the elements are either α or β emitters.

In March 2014, Giuseppe Levi and others carried out a month-long test of Andrea Rossi's E-Cat. Rossi has claimed that the E-Cat can generate many watts of excess power with fuel consisting of nickel and hydrogen. Appendix 3 to the report for the test contains an isotopic analysis by Ulf Bexell and Josefin Hall that was carried out on the "fuel" and "ash" that went into and was taken out of the device [1]. Although the main details that were highlighted related to changes in lithium and nickel, a number of SIMS spectra were included which showed various mass peaks. Three of the spectra showed ions at masses $m \geq 100$, which might have been cluster ions or heavier nuclides. Here we look at the possibility that several ranges of peaks correspond to heavier nuclides.

The three spectra with mass peaks at $m \geq 100$ have somewhat different counts. One of them was obtained before the surface and any carbon adhesive sticker on it had been sputtered off. For this reason we will not consider that spectrum. Following are approximate counts for mass peaks in the two other spectra in Appendix 3 showing masses at $m \geq 100$ that are explicitly called out by Bexell and Hall:

Mass peak[a]	Possible nuclides	Approx. counts Fig. 7	Fig. 8
105	^{105}Pd	1600	1500
115	^{115}In, ^{115}Sn	2600	?
117	^{117}Sn	?	3000
128	^{128}Te, ^{128}Xe	1600	2000
133	^{133}Cs	2500	3500
141	^{141}Pr	1800	2000
147	^{147}Sm	900	24000
156	^{156}Gd, ^{156}Dy	2400	?
165	^{165}Ho	800	?
173	^{173}Yb	400	?
178	^{178}Hf	600	?
187	^{187}Re, ^{187}Os	400	?
207	^{207}Pb	?	4500
221	No long-lived nuclides.	?	4000

[a] Mass peaks above 238 omitted.

Table 1: Mass peaks in the fuel at $m \geq 100$ in Appendix 3 to Levi *et al.*, after sputtering [1].

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Unlike the graphs for the spectra showing masses at $m < 100$, for which a vertical bar appears to correspond one-to-one with a mass peak, it seems that vertical bars in the graphs for masses at $m \geq 100$ do not have a clean one-to-one correspondence with an integral mass number. It will be difficult for this reason to guess at the counts for mass peaks that are not explicitly labeled in the graphs. In Table 1 we will just leave a "?" with the understanding that there were potentially significant counts at these mass peaks as well as ones not listed in the table, even though such peaks were not labeled.

For the sake of simplicity, let us assume that elements in Table 1, if they were actually in the fuel, were present in their natural abundances and were not isotopically enriched. Table 2 provides the natural abundances for elements in Table 1, as well as for tungsten, which has been mentioned as another possible ingredient in the fuel [2, 3]. Included as well is the total count for the element that the amount of isotope implies, working backwards from the natural abundance, which is taken from Wikipedia. An asterisk has been placed next to the minimum amount across all isotopes for an element, which can give us a rough sense of the upper bound on the ion count for the element in the two spectra, and, from this, an idea of the relative amount should the element have been present. In contrast to Table 1, in Table 2 we have attempted a very rough guess at the amounts for mass peaks not explicitly labeled in the spectra in order to obtain some kind of upper bound for the ion count, usually overestimating in the process. Figure 7 was generally used in preference to Figure 8.

Table 3 summarizes the information in Table 2 and indicates whether an element is an α or β emitter, with the half-life and natural abundance in parentheses for decaying isotopes. In several cases α decay is energetically possible but the half-life either is only theoretical or is unavailable. From Table 3 we can see that the peaks in Figure 7 are consistent with the presence of small amounts of samarium, gadolinium, hafnium, tungsten, osmium, rhenium, and lead, all of which are α emitters. The α or β decay activity of an element in the fuel will be a function of the amount of the element, the half-lives and natural abundances of the unstable isotopes, and, if it can be accomplished, the extent to which decay can be induced.

References

[1] G. Levi et al. *Observation of Abundant Heat Production from a Reactor Device and of Isotopic Changes in the Fuel*. 2014. URL: http://www.elforsk.se/Global/Omv%C3%83%C2%A4rld_system/filer/LuganoReportSubmit.pdf.

[2] Frank Acland. *Norman Cook on E-Cat Fuel Elements (Tungsten and Iron mentioned)*. URL: http://www.e-catworld.com/2015/11/29/norman-cook-on-e-cat-fuel-elements-tungsten-and-iron-mentioned/.

[3] Japan CF-Research Society. *JCF16 Abstracts*. URL: http://jcfrs.org/JCF16/jcf16-abstracts.pdf.

Elem.	A	NA (%)	Max count	Implied total
Pd	102	1.02	400	3.9e4
	104	11.14	900	8.1e3
	105	22.33	1500	6.7e3
	106	27.33	400	1.5e3*
	107	trace	0	–
	108	26.46	400	1.5e3
	110	11.72	400	3.4e3
In	113	4.29	400	9.3e3
	115	95.71	2600	2.7e3*
Sn	112	0.97	400	4.1e4
	114	0.66	400	6.1e4
	115	0.34	2600	7.6e5
	116	14.54	2100	1.4e4
	117	7.68	2100	2.7e4
	118	24.22	2100	8.7e3
	119	8.59	1000	1.2e4
	120	32.58	400	1.2e3*
	122	4.63	400	8.6e3
	124	5.79	400	6.9e3
	126	trace	0	–
Te	120	0.09	400	4.4e5
	122	2.55	400	1.6e4
	123	0.89	400	4.5e4
	124	4.74	400	8.4e3
	125	7.07	400	5.7e3
	126	18.84	1000	5.3e3
	128	31.74	1600	5.0e3
	130	34.08	1500	4.4e3*
Xe	124	0.095	400	4.2e5
	126	0.089	1000	1.1e6
	128	1.91	1600	8.4e4
	129	26.4	1600	6.1e3
	130	4.07	400	9.8e3
	131	21.2	1500	7.1e3
	132	26.9	300	1.1e3*
	134	10.4	400	3.8e3
	136	8.86	200	2.3e3
Cs	133	100	2500	2.5e3*
	135	trace	0	–
	137	trace	0	–
Pr	141	100	1800	1.8e3*
Sm	144	3.07	800	2.6e4
	146	trace	0	–
	147	14.99	900	6.0e3
	148	11.24	300	2.7e3
	149	13.82	300	2.2e3*
	150	7.38	400	5.4e3
	152	26.75	600	2.2e3
	154	22.75	1000	4.4e3

Elem.	A	NA (%)	Max count	Implied total
Gd	152	0.20	400	2.0e5
	154	2.18	1000	4.6e4
	155	14.80	1000	6.8e3
	156	20.47	2400	1.2e4
	157	15.65	600	3.8e3
	158	24.84	200	8.1e2*
	160	21.86	200	9.1e2
Dy	156	0.06	2400	4.0e6
	158	0.10	600	6.0e5
	160	2.34	200	8.5e3
	161	18.91	200	1.1e3*
	162	25.51	400	1.6e3
	163	24.90	400	1.6e3
	164	28.18	400	1.4e3
Ho	165	100	800	8.0e2*
Yb	168	0.13	500	3.8e5
	170	3.04	400	1.3e4
	171	14.28	300	2.1e3
	172	21.83	300	1.4e3
	173	16.13	400	2.5e3
	174	31.83	300	9.4e2*
	176	12.76	400	3.1e3
Hf	174	0.162	400	2.5e5
	176	5.206	400	7.7e3
	177	18.606	500	2.7e3
	178	27.297	600	2.2e3
	179	13.629	500	3.7e3
	180	35.1	400	1.1e3*
	182	trace	0	–
W	180	0.12	400	3.3e5
	182	26.5	300	1.1e3
	183	14.31	200	1.4e3
	184	30.64	200	6.5e2*
	186	28.43	400	1.4e3
Os	184	0.02	400	2.0e6
	186	1.59	400	2.5e4
	187	1.96	400	2.0e4
	188	13.24	400	3.0e3
	189	16.15	400	2.5e3
	190	26.26	400	1.5e3
	192	40.78	400	9.8e2*
Re	185	37.4	400	1.1e3
	187	62.6	400	6.4e2*
Pb	204	1.4	500	3.6e4
	206	24.1	500	2.1e3
	207	22.1	4500	2.0e4
	208	52.4	500	9.5e2*
	210	trace	0	–

Table 2: Natural abundances for elements listed in Table 1.

Elem.	Upper bound of count	Decay modes
Pd	1.5e3	β^- (6.5e6 y, trace), $\beta^-\beta^-$ (>6e17 y, 11.7%)
In	2.7e3	β^- (4.4e14 y, 95.7%)
Sn	1.2e3	β^- (2.3e5 y, trace)
Te	4.4e3	$\beta^-\beta^-$ (7.9e20 y, 34.1%), $\beta^-\beta^-$ (2.2e24, 31.7%)
Xe	1.1e3	$\beta^-\beta^-$ (2.2e21 y, 8.9%)
Cs	2.5e3	β^- (2.3e6 y, trace), β^- (30.17 y, trace)
Pr	1.8e3	
Sm	2.2e3	α (1.0e8 y, trace), α (1.1e11 y, 15.0%), α (7e15 y, 11.2%)
Gd	1.8e2	α (1.08e14 y, 0.2%)
Dy	1.1e3	(α)
Ho	8.0e2	(α)
Yb	9.4e2	(α)
Hf	1.1e3	α (2e15 y, 0.2%), β^- (8.9e6 y, trace)
W	6.5e2	α (1.8e18 y, 0.12%)
Os	9.8e2	α (2.0e15 y, 1.6%)
Re	6.4e2	α (4.1e10 y, 62.6%), β^- (4.1e10 y, 62.6%)
Pb	9.5e2	α (22.3 y, trace), β^- (22.3 y, trace)

Table 3: Upper-bound counts for various elements potentially in fuel relative to those shown in Figure 7.