Isotopes of strontium

The alkaline earth metal strontium ($_{38}$Sr) has four stable, naturally occurring isotopes: ^{84}Sr (0.56%), ^{86}Sr (9.86%), ^{87}Sr (7.0%) and ^{88}Sr (82.58%). Its standard atomic weight is 87.62(1).

Main isotopes of strontium ($_{38}$Sr)

Isotope			Decay	
	abundance	half-life ($t_{1/2}$)	mode	product
^{82}Sr	syn	25.36 d	ε	^{82}Rb
^{83}Sr	syn	1.35 d	ε	^{83}Rb
			$β^+$	^{83}Rb
			γ	–
^{84}Sr	0.56%	stable		
^{85}Sr	syn	64.84 d	ε	^{85}Rb
			γ	–
^{86}Sr	9.86%	stable		
^{87}Sr	7.00%	stable		
^{88}Sr	82.58%	stable		
^{89}Sr	syn	50.52 d	$β^−$	^{89}Y
^{90}Sr	trace	28.90 y	$β^−$	^{90}Y

Standard atomic weight $A_{r,\,\text{standard}}$(Sr) 87.62(1)[1]

Only ^{87}Sr is radiogenic; it is produced by decay from the radioactive alkali metal ^{87}Rb, which has a half-life of 4.88 × 10^{10} years (i.e. more than three times longer than the current age of the universe). Thus, there are two sources of ^{87}Sr in any material: primordial, formed during nucleosynthesis along with ^{84}Sr, ^{86}Sr and ^{88}Sr; and that formed by radioactive decay of ^{87}Rb. The ratio ^{87}Sr/^{86}Sr is the parameter typically reported in geologic investigations; ratios in minerals and rocks have values ranging from about 0.7 to greater than 4.0 (see rubidium–strontium dating). Because strontium has an electron configuration similar to that of calcium, it readily substitutes for Ca in minerals.

In addition to the four stable isotopes, thirty-two unstable isotopes of strontium are known to exist (see Table, below). Strontium decays into its neighbours yttrium (lower neighbour) and rubidium (upper neighbour).

The longest-lived of these isotopes, and the most relevantly studied are ^{90}Sr with a half-life of 28.9 years and ^{85}Sr with a half-life of 64.853 days. Of importance are also strontium-89 (^{89}Sr) with a half-life of 50.57 days. They decay with:

$$^{89}_{38}\mathrm{Sr} \longrightarrow {}^{89}_{39}\mathrm{Y} + e^- + \bar{\nu}_e$$
$$^{90}_{38}\mathrm{Sr} \longrightarrow {}^{90}_{39}\mathrm{Y} + e^- + \bar{\nu}_e$$

^{89}Sr is an artificial radioisotope used in treatment of bone cancer. In circumstances where cancer patients have widespread and painful bony metastases, the administration of ^{89}Sr results in the delivery of beta particles directly to the area of bony problem, where calcium turnover is greatest.

^{90}Sr is a by-product of nuclear fission, present in nuclear fallout. The 1986 Chernobyl nuclear accident contaminated a vast area with ^{90}Sr.[2] It causes health problems, as it substitutes for calcium in bone, preventing expulsion from the body. Because it is a long-lived high-energy beta emitter, it is used in SNAP (Systems for Nuclear Auxiliary Power) devices. These devices hold promise for use in spacecraft, remote weather stations, navigational buoys, etc., where a lightweight, long-lived, nuclear-electric power source is required.

The lightest known isotope is ^{73}Sr and the heaviest is ^{108}Sr.

All other strontium isotopes have half-lives shorter than 55 days, most under 100 minutes.

List of isotopes

Nuclide [n 1]	Z	N	Isotopic mass (Da) [n 2][n 3]	Half-life [n 4]	Decay mode [n 5]	Daughter isotope [n 6][n 7]	Spin and parity [n 8][n 4]	Natural abundance (mole fraction)	
	Excitation energy							Normal proportion	Range of variation
^{73}Sr	38	35	72.96597(64)#	>25 ms	$β^+$ (>99.9%)	^{73}Rb	1/2−#		
					$β^+$, p (<.1%)	^{72}Kr			
^{74}Sr	38	36	73.95631(54)#	50# ms [>1.5 μs]	$β^+$	^{74}Rb	0+		
^{75}Sr	38	37	74.94995(24)	88(3) ms	$β^+$ (93.5%)	^{75}Rb	(3/2−)		
					$β^+$, p (6.5%)	^{74}Kr			
^{76}Sr	38	38	75.94177(4)	7.89(7) s	$β^+$	^{76}Rb	0+		
^{77}Sr	38	39	76.937945(10)	9.0(2) s	$β^+$ (99.75%)	^{77}Rb	5/2+		
					$β^+$, p (.25%)	^{76}Kr			
^{78}Sr	38	40	77.932180(8)	159(8) s	$β^+$	^{78}Rb	0+		
^{79}Sr	38	41	78.929708(9)	2.25(10) min	$β^+$	^{79}Rb	3/2(−)		
^{80}Sr	38	42	79.924521(7)	106.3(15) min	$β^+$	^{80}Rb	0+		
^{81}Sr	38	43	80.923212(7)	22.3(4) min	$β^+$	^{81}Rb	1/2−		
^{82}Sr	38	44	81.918402(6)	25.36(3) d	EC	^{82}Rb	0+		
^{83}Sr	38	45	82.917557(11)	32.41(3) h	$β^+$	^{83}Rb	7/2+		
^{83m}Sr	259.15(9) keV			4.95(12) s	IT	^{83}Sr	1/2−		
^{84}Sr	38	46	83.913425(3)	**Observationally Stable**[n 9]			0+	0.0056	0.0055–0.0058
^{85}Sr	38	47	84.912933(3)	64.853(8) d	EC	**^{85}Rb**	9/2+		
^{85m}Sr	238.66(6) keV			67.63(4) min	IT (86.6%)	^{85}Sr	1/2−		
					$β^+$ (13.4%)	**^{85}Rb**			
^{86}Sr	38	48	85.9092607309(91)	**Stable**			0+	0.0986	0.0975–0.0999
^{86m}Sr	2955.68(21) keV			455(7) ns			8+		
^{87}Sr[n 10]	38	49	86.9088774970(91)	**Stable**			9/2+	0.0700	0.0694–0.0714
^{87m}Sr	388.533(3) keV			2.815(12) h	IT (99.7%)	**^{87}Sr**	1/2−		
					EC (.3%)	***^{87}Rb***			
^{88}Sr[n 11]	38	50	87.9056122571(97)	**Stable**			0+	0.8258	0.8229–0.8275
^{89}Sr[n 11]	38	51	88.9074507(12)	50.57(3) d	$β^−$	**^{89}Y**	5/2+		
^{90}Sr[n 11]	38	52	89.907738(3)	28.90(3) y	$β^−$	^{90}Y	0+		
^{91}Sr	38	53	90.910203(5)	9.63(5) h	$β^−$	^{91}Y	5/2+		
^{92}Sr	38	54	91.911038(4)	2.66(4) h	$β^−$	^{92}Y	0+		
^{93}Sr	38	55	92.914026(8)	7.423(24) min	$β^−$	^{93}Y	5/2+		
^{94}Sr	38	56	93.915361(8)	75.3(2) s	$β^−$	^{94}Y	0+		
^{95}Sr	38	57	94.919359(8)	23.90(14) s	$β^−$	^{95}Y	1/2+		
^{96}Sr	38	58	95.921697(29)	1.07(1) s	$β^−$	^{96}Y	0+		
^{97}Sr	38	59	96.926153(21)	429(5) ms	$β^−$ (99.95%)	^{97}Y	1/2+		
					$β^−$, n (.05%)	^{96}Y			
^{97m1}Sr	308.13(11) keV			170(10) ns			(7/2)+		
^{97m2}Sr	830.8(2) keV			255(10) ns			(11/2−)#		
^{98}Sr	38	60	97.928453(28)	0.653(2) s	$β^−$ (99.75%)	^{98}Y	0+		
					$β^−$, n (.25%)	^{97}Y			
^{99}Sr	38	61	98.93324(9)	0.269(1) s	$β^−$ (99.9%)	^{99}Y	3/2+		
					$β^−$, n (.1%)	^{98}Y			
^{100}Sr	38	62	99.93535(14)	202(3) ms	$β^−$ (99.02%)	^{100}Y	0+		
					$β^−$, n (.98%)	^{99}Y			
^{101}Sr	38	63	100.94052(13)	118(3) ms	$β^−$ (97.63%)	^{101}Y	(5/2−)		

					β^-, n (2.37%)	^{100}Y			
^{102}Sr	38	64	101.94302(12)	69(6) ms	β^- (94.5%)	^{102}Y	0+		
					β^-, n (5.5%)	^{101}Y			
^{103}Sr	38	65	102.94895(54)#	50# ms [>300 ns]	β^-	^{103}Y			
^{104}Sr	38	66	103.95233(75)#	30# ms [>300 ns]	β^-	^{104}Y	0+		
^{105}Sr	38	67	104.95858(75)#	20# ms [>300 ns]					
^{106}Sr[3]	38	68							
^{107}Sr[3]	38	69							
^{108}Sr[4]	38	70							

1. ^{m}Sr – Excited nuclear isomer.
2. ( ) – Uncertainty (1σ) is given in concise form in parentheses after the corresponding last digits.
3. # – Atomic mass marked #: value and uncertainty derived not from purely experimental data, but at least partly from trends from the Mass Surface (TMS).
4. # – Values marked # are not purely derived from experimental data, but at least partly from trends of neighboring nuclides (TNN).
5. Modes of decay:
   - EC: Electron capture
   - IT: Isomeric transition
   - n: Neutron emission
   - p: Proton emission
6. ***Bold italics symbol*** as daughter – Daughter product is nearly stable.
7. **Bold symbol** as daughter – Daughter product is stable.
8. ( ) spin value – Indicates spin with weak assignment arguments.
9. Believed to decay by $\beta^+\beta^+$ to ^{84}Kr
10. Used in rubidium–strontium dating
11. Fission product

References

1. Meija, Juris; et al. (2016). "Atomic weights of the elements 2013 (IUPAC Technical Report)" (https://doi.org/10.1515%2Fpac-2015-0305). *Pure and Applied Chemistry*. **88** (3): 265–91. doi:10.1515/pac-2015-0305 (https://doi.org/10.1515%2Fpac-2015-0305).
2. Wilken, R.D.; Diehl, R. (1987). "Strontium-90 in environmental samples from Northern Germany before and after the Chernobyl accident" (https://inis.iaea.org/search/search.aspx?orig_q=RN:19040220). *Radiochimica Acta*. **4** (4): 157–162.
3. Ohnishi, Tetsuya; Kubo, Toshiyuki; Kusaka, Kensuke; et al. (2010). "Identification of 45 New Neutron-Rich Isotopes Produced by In-Flight Fission of a ^{238}U Beam at 345 MeV/nucleon" (https://journals.jps.jp/doi/10.1143/JPSJ.79.073201). *J. Phys. Soc. Jpn*. Physical Society of Japan. **79** (7). doi:10.1143/JPSJ.79.073201 (https://doi.org/10.1143%2FJPSJ.79.073201).
4. Sumikama, T.; et al. (2021). "Observation of new neutron-rich isotopes in the vicinity of ^{110}Zr" (https://journals.aps.org/prc/abstract/10.1103/PhysRevC.103.014614). *Physical Review C*. **103** (1). doi:10.1103/PhysRevC.103.014614 (https://doi.org/10.1103%2FPhysRevC.103.014614).

- Isotope masses from:
  - Audi, Georges; Bersillon, Olivier; Blachot, Jean; Wapstra, Aaldert Hendrik (2003), "The NUBASE evaluation of nuclear and decay properties" (https://hal.archives-ouvertes.fr/in2p3-00020241/document), *Nuclear Physics A*, **729**: 3–128, Bibcode:2003NuPhA.729....3A (https://ui.adsabs.harvard.edu/abs/2003NuPhA.729....3A), doi:10.1016/j.nuclphysa.2003.11.001 (https://doi.org/10.1016%2Fj.nuclphysa.2003.11.001)
- Isotopic compositions and standard atomic masses from:
  - de Laeter, John Robert; Böhlke, John Karl; De Bièvre, Paul; Hidaka, Hiroshi; Peiser, H. Steffen; Rosman, Kevin J. R.; Taylor, Philip D. P. (2003). "Atomic weights of the elements. Review 2000 (IUPAC Technical Report)" (https://doi.org/10.1351%2Fpac200375060683). *Pure and Applied Chemistry*. **75** (6): 683–800. doi:10.1351/pac200375060683 (https://doi.org/10.1351%2Fpac200375060683).
  - Wieser, Michael E. (2006). "Atomic weights of the elements 2005 (IUPAC Technical Report)" (https://doi.org/10.1351%2Fpac200678112051). *Pure and Applied Chemistry*. **78** (11): 2051–2066. doi:10.1351/pac200678112051 (https://doi.org/10.1351%2Fpac200678112051). Lay summary (http://old.iupac.org/news/archives/2005/atomic-weights_revised05.html).
- Half-life, spin, and isomer data selected from the following sources.
  - Audi, Georges; Bersillon, Olivier; Blachot, Jean; Wapstra, Aaldert Hendrik (2003), "The NUBASE evaluation of nuclear and decay properties" (https://hal.archives-ouvertes.fr/in2p3-00020241/document), *Nuclear Physics A*, **729**: 3–128,

Bibcode:2003NuPhA.729....3A (https://ui.adsabs.harvard.edu/abs/2003NuPhA.729....3A), doi:10.1016/j.nuclphysa.2003.11.001 (https://doi.org/10.1016%2Fj.nuclphysa.2003.11.001)

- National Nuclear Data Center. "NuDat 2.x database" (http://www.nndc.bnl.gov/nudat2/). Brookhaven National Laboratory.
- Holden, Norman E. (2004). "11. Table of the Isotopes". In Lide, David R. (ed.). *CRC Handbook of Chemistry and Physics* (85th ed.). Boca Raton, Florida: CRC Press. ISBN 978-0-8493-0485-9.