Supplementary Table *Summary of planetary X-ray and nuclear spectroscopy missions deploying radiation instrumentation and links to the archived data.*
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X-ray spectroscopy mission	Country / Program	Launch	End of mission	Mission duration	Target	Orbit	Integration time	Payload description	Results	Data Archive
Luna 10	U.S.S.R. Soviet Academy of Sciences	31 March 1966	30 May 1966 (last contact)	60 days	Moon	Insertion: 3 April 1966 at 18:44 Perilune: 2088 km Apolune: 2738 km Inclination: 71.9° Period 178.05 m	56 days 460 orbits 219 data transmissions	Geiger counters (window: organic 1.1 mg cm^{-2}; Al filter 2.7 mg cm^{-2}; area 0.5 cm^2; FOV 1 sr) {three counters each}	Characteristic fluorescence lines of Si, Al, and Mg from the lunar surface excited by solar X-rays	Not available
Luna 12	U.S.S.R. Soviet Academy of Sciences	22 October 1966	19 January 1967 (last contact)	89 days	Moon	Insertion: 25 October 1966 at 20:45 Perilune: 1871 km Apolune: 2938 km Inclination: 10° Period 205 m	86 days 602 orbits 302 data transmissions	Geiger counters (window: organic 1.1 mg cm^{-2}; Al filter 2.7 mg cm^{-2}; area 0.5 cm^2; FOV 1 sr) {three counters each}	Characteristic fluorescence lines fluxes from the lunar surface excited by solar X-rays, estimated the cosmic ray background.	Not available
Apollo 15	U.S. NASA	26 July 1971	7 August 1971 at 20:45	12.3 days	Moon	Insertion: 29 July 1971 at 20:05 Perilune: 88.19 km Apolune: 104.93 km Inclination: 23° Period 117.73 m Departure: 4 August 1971 at 21:22	6.05 days 74 orbits 10.3 days (Apollo 15 and 16 combined)	Gas proportional counters (GPCs, three, area 25 cm^2) with Be windows (25.4 μm) Unfiltered, Mg (4.5 μm) and Al (6.3 μm) filters	Maps of Al/Si and Mg/Si ratios	http://pds-geosciences.wustl.edu/missions/apollo/
Apollo 16	U.S. NASA	16 April 1972	27 April 1972 at 19:45	11.1 days	Moon	Insertion: 19 April 1972 at 20:22 Perilune: 20.2 km Apolune: 108.3 km Inclination: 32.54° Period: 177.95 m Departure: 25 April 1972 at 02:15	4.25 days 64 orbits 10.3 days (Apollo 15 and 16 combined)	Gas proportional counters (GPCs, three, area 25 cm^2) with Be windows (25.4 μm) Unfiltered, Mg (4.5 μm) and Al (6.3 μm) filters	Maps of Al/Si and Mg/Si ratios	http://pds-geosciences.wustl.edu/missions/apollo/
Near Earth Asteroid Rendezvous (NEAR)	U.S. NASA	17 February 1996	28 February 2001 at ~00:00	5 years	433 Eros	Insertion: 14 Feb 2000 at 15:33 High orbit: 200 km Medium orbit 100 km Low polar orbit 50 km High equatorial orbit: 50 to 500 km Low altitude orbit 35 km Landing date: 12 February 2001 at 20:01	363 days 230 orbits	Gas proportional counters (GPCs, three, area 25 cm^2) with Be windows (25 μm) Unfiltered, Mg (8.5 μm) and Al (8.5 μm) filters	Elemental abundance ratio maps of Mg/Si, Al/Si, Ca/Si, and Fe/Si; primitive chondritic composition.	https://sbn.psi.edu/pds/resource/near/
MUSES-C (Hayabusa)	Japan Japan Aerospace Exploration Agency	9 May 2003	Remote sensing: 12 November 2005 Sample return: 13 June 2010	7.1 years	25143 Itokawa	Insertion: 12 Sept 2005 at 01:17 Distance: 55 m to 20 km Landing date: 19 November 2005 at 21:30	38 days	Charge-coupled devices (CCDs, four, 25 cm^2) 1024×1024 pixels (each pixel size: 24 μm^2)	Elemental abundance ratios of Mg/Si and Al/Si; no substantial regional differences.	http://darts.isas.jaxa.jp/pub/hayabusa/
Small Missions for Advanced Research and Technology-1 (SMART-1)	European Space Agency	27 September 2003	3 September 2006 (impact)	2.9 years	Moon	Insertion: 15 Nov 2004 Perilune: 2205 km Apolune: 4600 km Inclination: 90.26° Period: 4.95 hours	657 days	Swept charge devices (SCDs, 24, 14 cm^2), organized in three facets of 8; Facet 1&2 Al filter 4000 angstrom; Facet 3 Mg filter 0.006 mm.	Mg, Al, Si, and Fe measured during solar flare events, including the first unambiguous detection of Ca by X-rays.	https://archives.esac.esa.int/psa/
MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER)	U.S. NASA	3 August 2004	30 April 2015 (impact)	10.8 years	Mercury	Insertion: 18 March 2011 at 01:00; entered service: 4 April 2011 Phase 1 (12 months) Perihermion: 200 km Apohermion: 15193 km Inclination: 82.5° Period: 12 h Phase 2 (12 months) Perihermion: 278 km Apohermion: 10314 km Inclination: 84° Period: 8 h Phase 3 (24 months 43 days) Perihermion: 183 to < 25 km Apohermion: 10314 km Inclination: 84° Period: 8 h	4 years	Gas proportional counters (GPCs, three, area 10 cm^2) with Be windows (25 μm) Unfiltered, Mg (4.5 μm) and Al (6.3 μm) filters	Maps of elemental abundances and ratios including Mg, Al, Si, S, Ca, Ti, and Fe.	http://pds-geosciences.wustl.edu/missions/messenger/grns.htm
SELENE (Kaguya)	Japan Japan Aerospace Exploration Agency	14 September 2007	10 June 2009 (impact)	1.8 years	Moon	Insertion: 3 October 2007 High altitude (16 month) Altitude: 100 km, circular Inclination: 90° Period: 2 h Low altitude (4 months) Altitude: 30 × 50 km Inclination: 90°	1.6 years	Charge-coupled devices (CCDs, four, effective area 100 cm^2) 1024×1024 pixels (each pixel size: 24 μm^2)	Limited data acquisition due to radiation damage and solar cycle minimum	Not available
Chang'e-1	P.R.C. China National Space Administration	24 October 2007	1 March 2009 (impact)	1.3 years	Moon	Insertion: 5 November 2007 Altitude: 200 km Inclination: 64° Period: 2.12 hours	1.3 years	Si-PIN detectors soft X-ray: (four, 1 cm^2) Be filter 12.5 μm hard X-ray: (sixteen, 16 cm^2) Al filter 1.0 μm	Limited data acquisition due to radiation damage and solar cycle minimum. During solar flare events, Mg, Al, Si, and Ca were observed.	http://159.226.88.59/index_en.jsp
Chandrayaan-1	India Indian Space Research Organization	22 October 2008	28 August 2009 (lost contact)	310 days	Moon	Insertion: 8 November 2008 Altitude: 100, 200 km Inclination: 90° Period: 1.968 hours	293 days 3400 orbits	Swept charge devices (SCDs, 24, 14 cm^2) Organized in three facets of 8 Facet 1&2 Al filter 4000 Å Facet 3 Mg filter 6 μm	Surface abundances of Mg, Al, Si, Ca and Fe for highland regions.	Not available
Chang'e-2 (lunar orbiter)	P.R.C. China National Space Administration	1 October 2010	8 June 2011 (orbital departure)	250 days	Moon	Insertion: 6 October 2010 at 03:06 Altitude: 100 km Inclination: 90° Period: 1.967 hours Departure: 8 June 2011	245 days	Si-PIN detectors soft X-ray: (four, 1 cm^2) Be filter 12.5 μm hard X-ray: (sixteen, 16 cm^2) Al filter 1.0 μm	Solar flare observation of Mg, Al, Si, Ca and Fe in Oceanus Procellarum	http://159.226.88.59/index_en.jsp
Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx)	U.S., NASA New Frontiers Program	8 September 2016	Ongoing (planned end date: 24 September 2023)		101955 Bennu	Insertion: 31 December 2018 Preliminary survey: 7 km circular polar Orbital A: 1.4 × 2.0 km elliptical orbit Orbital B: 1 km circular orbit Recon: 225-525 m Rehersal: minimum 125 m	2.3 years	Charged-coupled device (CCDs, four, effective area 24 cm^2) with a coded aperture mask	Goal: Global abundance maps to assist in sample site selection	Target archive: https://sbn.psi.edu/pds/
BepiColombo - Mercury Planetary Orbiter	Europe / Japan, European Space Agency and Japan Aerospace Exploration Agency	20 October 2018	Ongoing		Mercury	400 × 1500 km elliptical polar mapping orbit	1 year	Monolithic19.2 mm × 19.2 mm active pixel sensors (APS) with a collimator and an imaging telescope with microchannel plate X-ray optics.	Goal: Global maps of elemental abundances	Target archive: https://archives.esac.esa.int/psa/

Supplementary Table (*cont.*)

Nuclear spectroscopy mission	Country / Program	Launch date(s)	End of mission	Mission duration	Status	Target	Orbit	Mapping duration[a]	Gamma ray spectrometer	Neutron spectrometer	Results and/or Objectives[b]	Data archive
Apollo 15 and 16	U.S.	26-Jul-1971 16-Apr-1972	7-Aug-1971 27-Apr-1972	12 days 11 days	Completed	Moon	Equatorial orbit covering 20% of the lunar surface	10.5 days (Apollo 15 and 16 combined)	NaI(Tl) with plastic anticoincidence shield	None	Maps of major and radioactive elements, including Fe, Ti, and Th	Not available
Venera 8	U.S.S.R.	27-Mar-1972	22-Jul-1972	4 months	Completed	Venus	N/A: Descent module/lander	42 minutes of data acquisition on the surface	NaI(Tl)	None	Abundances of K, Th, and U; Found K/Th ratio similar to that of Earth rocks	Not available
Mars 5	U.S.S.R.	25-July-1973	28-Feb-1974	7 months	Completed	Mars	Elliptical, equatorial orbit, 1,760 km periapsis, 32,586 km apoapsis, 35° inclination	16 days	NaI(Tl) with plastic anticoincidence shield	None	Abundances of K, Th, and U; Found K, Th, U content corresponds to that of terrestial igneous rocks	Not available
Phobos II[c]	U.S.S.R.	12-July-1988	27-Mar-1989	15 months	Lost during Phobos encounter	Mars and Phobos	Elliptical, equatorial orbit, 900 km periapsis, 80,000 km apoapsis	2 orbits analyzed	CsI(Tl)	None	Abundances for O, Si, Fe, K and Th in two equatorial regions in the western hemisphere	Not available
Mars Observer	U.S., NASA Mars Exploration Program	25-Sep-1992	21-Aug-1993	11 months	Lost prior to orbital insertion	Mars	400-km altitude circular polar mapping orbit[b]	1 Mars year[b]	HPGe, passively cooled	Boron-loaded plastic scintillators	Global maps major elements and water-equivalent hydrogen (Objectives not achieved)	Not available
Near Earth Asteroid Rendezvous (NEAR)	U.S., NASA Discovery Program	17-Feb-1996	28-Feb-2001	5 years	Completed	433 Eros	N/A: Data acquired after successful landing	7 days on the surface	NaI(Tl) with BGO anticoincidence shield	None	Abundances for O, Mg, Si, Fe, and K	https://sbn.psi.edu/pds/resource/near/
Lunar Prospector	U.S., NASA Discovery Program	6-Jan-1998	31-July-1999	1.6 years	Completed mission by planned impact in a south polar crater	Moon	100-km and 30-km altitude circular polar mapping orbits	300 days at high altitude; 220 days at low altitude	BGO with boron-loaded plastic anticoincidence shield (the volume of the BGO crystal was about 300 cm^3)	^{3}He gas proportional counters and boron-loaded plastic scintillator	Discovery of enhanced water-equivalent hydrogen associated with polar cold traps; global maps of major and radioactive elements; K/Th ratio	http://pds-geosciences.wustl.edu/missions/lunarp/
2001 Mars Odyssey	U.S., NASA Mars Exploration Program	7-Apr-2001	ongoing		Completed primary mission; ongoing extended mission	Mars	400-km altitude circular polar mapping orbit	Over 6 Mars years completed; gamma ray spectra available through September of 2009	HPGe, passively cooled (the volume of the HPGe crystal is approximately 200 cm^3)	Boron-loaded plastic scintillators (NS); Stilbene and ^{3}He tubes (HEND[d])	Distribution of water-equivalent hydrogen and high-latitude stratigraphy; seasonal variations in CO_2 ice and noncondensable gasses; and global maps of major and radioactive elements	http://pds-geosciences.wustl.edu/missions/odyssey/grs.html
MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER)	U.S., NASA Discovery Program	3-Aug-2004	30-Apr-2015	10.7 years	Completed mission by planned impact into Mercury surface (30-Apr-2015)	Mercury	Elliptical polar mapping orbit with perihermion at 200-km altitude, 15,000-km apohermion	4 years	HPGe, actively cooled with borated-plastic anticoincidence shield	^{6}Li-loaded glass and boron-loaded plastic scintillator	Mapped elemental composition of the northern hemisphere; Detected large amounts of hydrogen, consistent with deposits of ice in permanently-shadowed polar craters	http://pds-geosciences.wustl.edu/missions/messenger/grns.htm
Dawn	U.S., NASA Discovery Program	27-Sep-2007	ongoing		Completed Vesta encounter; Extended mission underway at Ceres	4 Vesta and 1 Ceres	Survey, high, and low altitude circular polar mapping orbits; elliptical orbits with periapsis at 35 km altitude	5 months data acquisition at low altitude (210 km) around Vesta; 9 months data acquisition at low altitude (380 km) around Ceres	CdZnTe and BGO (the BGO crystal is similar in size to that of Lunar Prospector)	^{6}Li-loaded glass and boron-loaded plastic scintillators	Global elemental ratios confirm Vesta as the HED parent body; Discovered extensive hydrogen deposits on Vesta, consistent with exogenic delivery of hydrated minerals by carbonaceous chondrites; Search for water ice and evidence for aqueous alteration at Ceres	https://sbn.psi.edu/pds/resource/dawn/
SELENE (Kaguya)	Japan, Japan Aerospace Exploration Agency	14-Sep-2007	10-Jun-2009	1.8 years	Completed mission by planned impact into lunar surface (10-Jun-2009)	Moon	100-km altitude circular and 30- × 50-km altitude elliptical polar mapping orbits	8 months at high altitude; 4 month at low altitude	Actively-cooled HPGe with BGO and plastic anticoincidence shields (the HPGe crystal volume was about 250 cm^3)	None	Global maps of U, Th, K, and Ca, Fe. Maps of Ti, Si, Mg, Al, and H in preparation.	http://darts.isas.jaxa.jp/planet/pdap/selene/ Also in preparation for archive at PDS
Lunar Reconnaissance Orbiter (LRO)	U.S., NASA, Lunar Exploration Program	18-Jun-2009	ongoing		Completed primary mission; ongoing extended mission	Moon	50-km altitude circular and 20- × 165-km elliptical polar mapping orbits	ongoing	None	Eight ^{3}He tubes, four with passive shielding intended for collimation of epithermal neutrons (LEND[d])	Confirmed the presence of enhanced hydrogen at the lunar poles; efficacy of collimation debated	http://pds-geosciences.wustl.edu/missions/lro/lend.htm
Chang'E-1	China, China National Space Administration	24-Oct-2007	1-Mar-2009	1.4 years	Completed	Moon	200-km circular polar mapping orbit	~85 days accumulation time	CsI(Tl) with CsI(Tl) anticoincidence shields	None	Distribution of radioelements, confirming results of Lunar Prospector and SELENE	http://159.226.88.59/index_en.jsp
Chandrayaan-1	India, Indian Space Research Organization	22-Oct-2008	28-Aug-2009	10 months	Lost contact	Moon	100- and 200- km circular polar orbit	9 months	9×256 pixels of 2.5×2.5× 3 mm^3 CZT with CsI anticoincidence shield	None	Measurements of low-energy gamma rays (20-250 keV) from radioelements	Not available
Chang'E-2	China, China National Space Administration	1-Oct-2010	ongoing		Departed lunar orbit on 8-Jun-2011	Moon	100-km circular polar mapping orbit	178 days accumulation time	$LaBr_3$ with CsI(Tl) anticoincidence shields	None	Distribution of radioelements, confirming results of Lunar Prospector and SELENE	http://159.226.88.59/index_en.jsp
Mars Science Laboratory (MSL)	U.S., NASA Mars Exploration Program	26-Nov-2011	ongoing		Deployed within Gale crater; first drive 22-Aug-2012; Data acquired within the 400 m traverse completed in the first 90 sols	Mars	N/A	1 Mars Year (5- to 20-km traverse)	None	^{3}He tubes with active neutron interrogation with a pulsed, 14-MeV, D-T neutron generator (DAN[e])	Preliminary results presented for WEH abundance, H-layering, and the abundance of neutron absorbing elements	http://pds-geosciences.wustl.edu/missions/msl/dan.htm
ExoMars Trace Gas Orbiter	Europe / Russia, European Space Agency and Roscosmos	14-Mar- 2016	ongoing		Orbit insertion: 19-Oct-2016	Mars	400-km polar circular orbit	ongoing	None	Design based on LEND[d]	Goals: (1) Mapping water in the subsurface, (2) measuring seasonal CO_2 deposition at both poles, (3) monitoring galactic cosmic ray and solar particle events	https://archives.esac.esa.int/psa/
BepiColombo - Mercury Planetary Orbiter	Europe / Japan, European Space Agency and Japan Aerospace Exploration Agency	20-Oct-2018	ongoing			Mercury	400- × 1500-km elliptical polar mapping orbit[b]	1 year[b]	$CeBr_3$ scintillator[d]	Design based on HEND[d]	Global maps of elemental abundances[b]	Target archive: https://archives.esac.esa.int/psa/

[a] Refers to the time spent in orbit

[b] Objectives are listed for Mars Observer and BepiColumbo.

[c] Neutron and gamma ray spectrometers were flown on Phobos I, which was launched on 7-July-1988; however, Phobos I was lost during the cruise phase of the mission. The Mars 4 and 5 missions (U.S.S.R., 1973) flew identical sodium iodide gamma ray spectrometers. A few gamma ray spectra were acquired by Mars 5 while in an elliptical orbit around Mars (apoapsis 32,560 km, periapsis 1760 km, inclination 35° to the equator).

[d] The High Energy Neutron Detector (HEND) on Odyssey, the Lunar Exploration Neutron Detector (HEND) on LRO, the Dynamic Albedo of Neutron (DAN) instrument on MSL, the Fine Resolution Epithermal Neutron Detector (FREND) on ExoMars - Trace Gas Orbiter, and the Mercury Gamma-ray and Neutron Spectrometer (MGNS) on BepiColumbo - Mercury Planetary Orbiter were provided by the Russian Federation.