An Introduction to Space Instrumentation, Eds. K. Oyama and C.Z. Cheng, TERRAPUB, Tokyo, 2013, pp: 240, ISBN 978-4-88704-160-8. Price ¥15000 (incl. postage)

Japan and Canada were drawn into the space age, prior to Sputnik, by the desire to make space measurements during the International Geophysical Year, 1957-58. The Japanese K-6 rocket reached 60 km altitude during the IGY and by 1964 an Institute for Space and Aeronautical Science was established at the University of Tokyo and a rocket launch site at the Kagoshima Space Center. In Canada the USA established and operated a rocket launch site at Fort Churchill, Manitoba during the IGY. The first Canadian space instruments were launched from here in 1959 and the first Canadian made Black Brant rockets were test launched the same year. Almost in step, Canadian and Japanese space scientists collaborated over the years. But this beautifully produced book is only partly about the history, it is a contemporary description of space instrumentation, though some of it was developed over many years. It grew out of a workshop organized by the authors. The lead author, Koh-Ichiro Oyama was a pioneer in rocket instrumentation, developing a novel probe for ionospheric electron temperature measurement at the University of Tokyo beginning in 1970. After his formal retirement he moved to the National Cheng Kung University in Taiwan. There, he and his colleague Chio-Zhong Cheng organized a Taiwan-Japan Workshop on Space Instruments held in 2010. The countries of authors other than from Japan are identified in this review which highlights the strong overlap with Canadian space instrumentation.

The book contains 22 articles about instruments, many of which could be flown on rockets or satellites, but 17 of these are concerned primarily with rocket flights and 5 specifically with satellite instruments. These could be further categorized as: 13 articles on measurements of the ionized atmosphere (ionosphere) and 9 on the neutral atmosphere. Except for one on plasma wave receivers the ionosphere articles are all about local (in situ) measurements. The neutral measurements are also divided between remote sensing and local, 3 and 6 respectively.

Beginning with the local neutral atmosphere there are two articles using electron beam excitation. Strelnikov et al. (Germany) describe a CONE instrument, essentially an ionization gauge in which the ion current is an accurate measure of the neutral density while Kurihara et al. describe the ionization and excitation of N_2, into the (0,0) band of the N_2^+ First Negative system, producing prompt emission at 391.4 nm. By measuring the ratio of intensities of different rotational lines in the band it is possible to determine the rotational temperature, equivalent to the local kinetic temperature. This ingenious experiment was pioneered in Canada by Jaap de Leeuw of the University of Toronto Institute for Aerospace Studies (UTIAS). Iwagami and Morrow outline the use of 130 nm ultraviolet lamp radiation to excite local atomic oxygen, giving a measure of the atomic oxygen concentration. This technique is familiar to Canadians as it was pioneered at York University by Bob Young and Bill Morrow; the lamps were fabricated by Resonance Ltd. in Barrie, Morrow’s company. In another article Iwagami describes the remote sensing of NO concentration in the atmosphere, using as a spectral filter an absorption cell containing NO gas, and in a further article an instrument for determining rocket attitude from

stars, as well as the measurement of Mg II ion airglow emission. Airglow measurement using filter photometers is described by Clemesha et al. (Brazil), for the observation of the $O(^1S)$ atomic oxygen green line emission at 557.7 nm, as well as the hydroxyl and sodium airglow emissions, using both longitudinal and side-looking photometers.

Three articles are devoted to the measurement of neutral winds using rockets. The first, by Koizumi-Kurihara et al. deploys thousands of 1 μm-thick plastic foils, coated with aluminum, called chaff, which is tracked from the ground by radar. The second, by Larsen (USA) is about releases of TMA (Trimethyl aluminum) which interact with the local atomic oxygen to become chemiluminescent. The resulting trail is photographed from several different locations, allowing its position to be accurately determined in three-dimensional space, providing wind measurements. This works only at night, against a dark sky, but a technique that works in the daytime is described by Habu, in releasing of lithium from canisters through heating from thermite. The lithium is detected through its resonance red line with narrow-band filter cameras against the daytime sky background. The spectacular cloud created and tracked for as long as 40 minutes is shown as the cover photo for the book.

An article by Abe and Oyama introduces the Langmuir probe for electron density measurement, providing a history of its development in Japan, with results from rocket flights and the Japanese satellite Akebono. Sinha (India) describes probe measurements of ionospheric irregularities and Oyama and Cheng follow with the development of the electron temperature probe, invented by Kunio Hirao in the seventies, flown in over 50 rocket flights, and on the Hinotori satellite. Wakabayashi et al. describe the absolute electron density probe impedance probe, attributed to Oya, but mentioning Owen Storey (who spent some time in Canada) and Keith Balmain of UTIAS. It uses RF to locate the upper hybrid plasma frequency. Piel (Germany) describes a resonance cone probe for electron density, temperature, drift speed and beam components. Fang and Cheng (Taiwan) describe a retarding potential analyser (RPA) for sounding rockets. On satellites the RPA takes advantage of the ram velocity of the satellite but on rockets a different approach is required. Ishisaka describes electric field measurements from a rocket, using 1 m long tubular probes of Be-Cu, based it would seem on the Alouette/ISIS long antennas, of some 45 m length. Takahashi (Brazil) describes the measurement of vector magnetic field from a rocket combined with a sun aspect sensor.

Moving specifically to satellites, Kazuma describes an energy analyzer for low energy electrons, using an MCP (multi-channel plate) intended for the LEP-e instrument on the ERG satellite, a radiation belt mission. Saito describes the All SKY-Electrostatic Analyzer low energy spectrometer for a 3-axis stabilized satellite, using scanning deflectors at the entrance and spherical/toroidal electrostatic deflectors inside. The application is MAP-PACE on the Japanese lunar orbiter Kaguya which spent 1.5 months in lunar orbit. The one Canadian contribution is by Andrew Yau et al. of the University of Calgary beginning with the Suprathermal Mass Spectrometer (SMS) flown on the Japanese Akebono satellite, developed by Brian Whalen of NRC, where a mass spectrometer was placed behind an RPA. Whalen's Hemispherical Electrostatic Analyzer (HEA) accepted ions or electrons over a wide range of energy and 360^o degrees of azimuth dispersed over an imaging detector. The resulting imaging CPA (cold plasma analyzer) was flown on the Swedish Freja satellite. The subsequent version incorporated a time-of-flight gate acting as an ion mass spectrometer in the TPA (Thermal Plasma Analyzer) flown

on the Japanese Nozomi spinning spacecraft, Japan's first Mars mission, also used in the IRM (imaging and rapid-scanning ion mass spectrometer) recently launched on the Canadian e-POP satellite. Matsuoka describes the development of flux gate magnetometers, specifically for the upcoming Bepi-Columbo mission to the planet Mercury. Finally, Kozima describes plasma wave receivers for satellites, referring to the pioneering work of Ron Barrington and Jack Belrose of CRC, with the Alouette I satellite, employed on the Geotail satellite, which carried three types of receivers, a swept frequency analyzer, a multichannel analyzer, and a waveform capture receiver.

An Introduction to Space Instrumentation provides a wealth of information for those involved in space instrumentation, or are just curious about it. It also reveals the many interactions between the Japanese and Canadian space programs, largely through one-on-one collaborations between the collaborating space scientists in the two countries. The author of this review would like to add his recognition of the many Japanese colleagues he worked with over the years, particularly Takao Tohmatsu, who was lost to our community far too early, in 1978. He hosted a Japanese dawn rocket flight in 1976 in which T. Mukai measured the flux of photoelectrons from the magnetically opposite sunlit ionosphere while a York University photometer observed the atomic oxygen red line airglow produced by those photoelectrons.

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