The Irshad Ahmed Khan Afridi Lecture delivered during *the Seventh International Conference on Space Science and Technology* (*ICSST 2023*), ISST, University of Karachi, Karachi, Pakistan and Department of Mathematics and Sciences, SSUET, Karachi, Pakistan, October 9, 10, 2023 (Monday, October 9, 2023, 1540h-1600h, Auditorium, Faculty of Arts and Social Sciences — Chinese Teachers' Memorial Auditorium, University of Karachi), Technical Session-II**:** Geo-Space Science Session, abstract#ICSST23-II-09**:** p 26

The Challenges of Astromathematics

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Astromathematics focuses on geometry to study orbits from a kinematical perspective. This branch of mathematics was introduced by the speaker on October 8, 2012 during the First National Conference on Space Sciences (NCSS 2012). In contrast to *astrodynamics*, the force expressions do not, explicitly, appear in the formulation of astromathamatics. Even if there appears a need to study force interactions, these are expressed as space-time-curvature equivalents. This formulation seems to be, generically, more suitable for accelerated frames governed by *geometrodynamics*. The Irshad Ahmed Khan Afridi memorial lecture covered the challenges of astromathematics faced during the current decade. With space entrepreneurship as the focus of ICCS 2023, this lecture emphasized the importance of developing commercial satellite-launching sites in Pakistan, which has the unique advantage of being near the equatorial circle, hence offering saving in fuel consumption as the velocity of earth rotation is added up in the velocity of satellites to be launched (Fig. 1). There was a general impression among the audience that Pakistan is using borrowed technology and not developing her own systems. This was, vehemently, contradicted by the speaker, who has worked in developing these technologies indigenously, in particular, explicit-guidance schemes (for a spacecraft approaching a destination, explicit-guidance scheme draws a path containing the current position of spacecraft, destination and center of earth in order to compute velocity vectors required to achieve the destination during the remaining transfer time) for satellite-launch vehicles, *viz.* the Lambert scheme with cross-range error included, the multistage-Lambert scheme, the inverse-Lambert scheme, the multistage-Q system, the inverse-Q system as well as the extended-Q system, through a deep study of astrodynamics and space-flight dynamics (the speaker was able to point out and communicate mistakes in Richard H. Battin's classic on the subject, who, very kindly, acknowledged them in his letter). Cross-product steering, put forward by Battin, was incomplete and needed an additional condition. This condition was added by the speaker and the new control law (a control law is a relation, which is implemented on the original system to make it perform according to pre-decided standards) was termed as the extended-cross-product steering, which was later adapted for the normal-component-cross-product steering. Further, the dot-product steering and the normal-component-dot-product steering were formulated (if the components of velocity perpendicular and normal to the desired orbit are made to vanish, the spacecraft shall remain in that orbit unless there is a perturbbation applied) and, finally, the ellipse-orientation steering (Fig. 2). Two-body problem in the elliptic-astrodynamical-coördinate mesh as well as the hyperbolic-astrodynamical-coördinate mesh has, already, been set up. Future challenges of astromathematics include formulating the two-body problem in the parabolic-astrodynamical-coördinate mesh. This should be followed by writing control laws and working out guidance schemes in these coördinate meshes. This lecture is dedicated to the loving memory of **Professor Dr. Irshad Ahmed Khan Afridi** (Fig. 3), born on Sunday, June 1, 1930 AC (Muharram-ul-Harām 4, 1349 AH) in Kaimganj (Qaimganj), District Farrukhabad, U. P., British India (speaker's father was, also, born in District Farukkabad) and passed away on Monday, October 18, 2010 (Dhu'l Qi'dah 10, 1431 AH) in Karachi, Sindh, Pakistan. His daughter, Talat Afridi, was my student in two courses in Department of Physics, University of Karachi and she was a close family friend till her untimely death. I met with Afridi Sahib through this connection and he motivated me to prepare PC-1 of Department of Space Science in University of Karachi, which I did through the help of Dr. Mohummed Ishaq Mirza, Member, Space Research, Pakistan Space and Upper Atmosphere Research Commission (SUPARCO). Later, when I joined Control-Systems Laboratories of SUPARCO (Plant), Professor Afridi contacted Professor Dr. Jawaid Quamar, who was Chairman, Department of Mathematics, University of Karachi at that time, to fulfill his vision. The later visualized an institute instead of a department and this laid the foundation of Institute of Space and Planetary Astrophysics (ISPA). Professor Quamar asked me to help in designing courses of the proposed institute. I spent many hours at his residence and later he invited me to join Department of Mathematics, University of Karachi, full time. I accepted his offer and joined the department on May 25, 1995 and remained there till my retirement on May 22, 2016. Professor Afridi obtained BSc (Honors) and MSc (Inorganic Chemistry) from University of Karachi, and PhD from University of Sheffield, England. He completed 3 post-doctorates one each from United States, Germany and Malaysia. He was, also, an approved Homeopathic Doctor. His notable PhD students include Najma Sultana (first PhD of Department of Chemistry, who later became Dean, Faculty of Pharmacy) and Zahida Parveen. He, also, helped educate general public about chemistry through his scientific articles published in JANG. In addition to establishing Space-Science Program in University of Karachi, Prof. Afridi was credited with preparing working papers for Departments of Computer Science and Soil Science in University of Karachi. His dream of making the first of these departments was materialized in 1984. After his retirement from University of Karachi, he helped establish Department of Pharmaceutical Chemistry at the Baqai Institute of Pharmaceutical Sciences, the Baqai Medical University. On June 4, 2015, a brief inaugural session took place at ISPA, in which the Founding Director of ISPA, Professor Dr. Jawaid Quamar inaugurated the ISPA Seminar Library in the memory of the person, who envisioned ISPA, now renamed as ISST. The new name "**Professor Dr. Irshad Ahmed Khan Afridi Seminar Library**" was approved by the Syndicate of University of Karachi.

Fig. 1. Delivering the I. A. K. Afridi memorial lecture

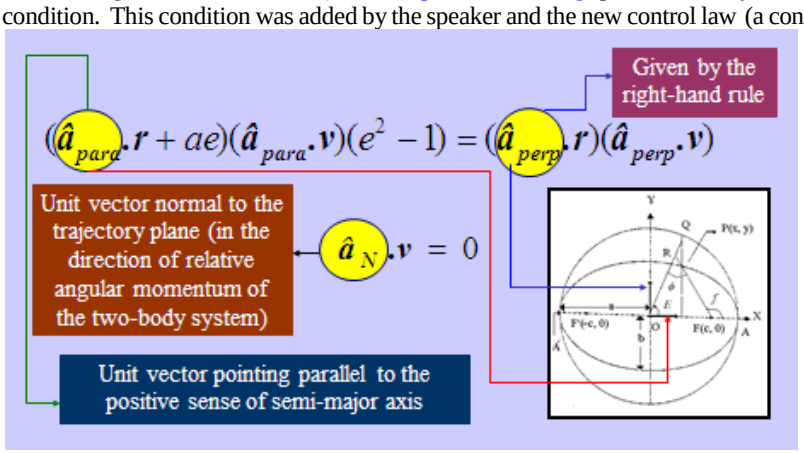

Fig. 2. Pictorial representation of the ellipse-orientation steering

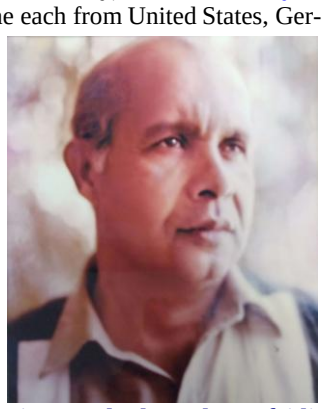

Fig. 3. Irshad A. Khan Afridi

*Keywords***:** Astrodynamics • Control laws • Down-range and cross-range errors • Explicit-guidance schemes • Orbit theory • Satellite-launch vehicle • Space-flight dynamics

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