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Astromathematics: A New Branch of Mathematics

Syed Arif Kamal
Department of Mathematics, University of Karachi, Karachi 75270, Pakistan; sakamal@uok.edu.pk

Prof. Dr. Syed Arif Kamal delivering opening lecture of CMS 2014 on March 20, 2014

'Astromathematics' was mentioned for the first time by the speaker (http://www.ngds-ku.org/Presentations/ISPA.pdf) on Monday, October 8, 2012, during *the First National Conference on Space Sciences*. It is a branch of mathematics, which focuses on geometrical aspects to study orbits from a kinematical perspective, in which the force expressions do not appear explicitly, but expressed as space-time-curvature equivalents. This formulation is capable of dealing with accelerated frames, governed by 'geometrodynamics'**:**

http://www.ngds-ku.org/Presentations/GenRelGrav.pdf

which is based on general theory of relativity put forward in 1915 (http://www.ngds-ku.org/Presentations/Ghori.pdf). 'Astronomy' is a discipline of natural science, which deals with celestial objects. Astronomical models are mental pictures based on geometric ideas (outlines visual framework of model), physical concepts (deals with the motions and the interactions of various parts the model), aesthetic notions (innate judgments of what seems beautiful) and basic assumptions that explain current observations and predict future observations, while verifiable by a variety of observations changeable to match observations better. Babylonians, Greeks, Chinese and Muslims all had their contributions to astronomy, which was given elegance by the monumental contributions of Galileo, Kepler and Newton. 'Astrodynamics', introduced by Samuel Herrick (1911-1974), is considered a branch of mathematics, which deals with calculating orbits to reach a given planet. Richard H. Battin remarks in the preface to his book, *An Introduction to the Mathematics and (the) Methods of Astrodynamics* (Revised Edition), "In the three centuries following Kepler and Newton, the world's greatest mathematicians brought, celestial mechanics to such an elegant state of maturity that, for several decades preceding the USSR's Sputnik in 1957, it all but disappeared from the university curriculum." The speaker got a chance study thoroughly First Edition (1987) of this book. On July 19, 1993, he prepared a review and sent to the author (http://www.ngds-ku.org/Papers/Battin.pdf), who answered on October 25, 1993, "Thank you very much for your letter and your interest in my book. I appreciate your list of corrections and suggestions." When the speaker joined University of Karachi in 1995, he taught Astronomy, Astrodynamics and Space-Flight Dynamics as well as conducted professional training courses at SUPARCO and Institute of Space Technology. He realized that the plane-polar coördinates are not the natural choice for setting up two-body problem (http://www.ngds-ku.org/pub/confabst.htm#C60:). He, then, formulated the Strong Noether's Theorem (http://www.ngds-ku.org/pub/confabst.htm#C61:), which states that if one sets up a problem close to natural symmetries of the system, one discovers additional constants-of-motion. In this spirit, planetary orbits were modeled using the elliptic-astrodynamical-coördinate mesh (http://www.ngds-ku.org/pub/confabst0.htm#C45:), which yielded 3 constants of motion. In addition, two-body problem has been formulated in the hyperbolic-astrodynamical-coördinate mesh, which is going to be presented today this afternoon (http://www.ngds-ku.org/Presentations/Hyperbolic.pdf). New control laws were devised — the extended-cross-product steering (http://www.ngds-ku.org/Papers/C56.pdf), the normal-component-cross-product steering, the dot-product steering (http://www.ngds-ku.org/Papers/C55.pdf), the normal-component-dot-product steering and the ellipse-orientation steering (http://www.ngds-ku.org/pub/confabst.htm#C64:). Cross-range-error correction was integrated in the Lambert scheme (http://www.ngds-ku.org/Papers/C67.pdf) as well as the multi-stage- and the inverse-Lambert schemes proposed (http://www.ngds-ku.org/Papers/C72.pdf) for course-plotting a satellite-launch vehicle. In addition, the multi-stage and the inverse-Q systems (http://www.ngds-ku.org/Papers/C66.pdf) were devised for steering a satellite-launch vehicle.

*Keywords***:** Two-body problem, strong Noether's theorem, elliptic-astrodynamical-coördinate mesh, multi-stage- and inverse-Lambert schemes, multi-stage- and inverse-Q systems, extended-cross-product steering, dot-product steering, ellipse-orientation steering

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Correspondence*:** Prof. Dr. Syed Arif Kamal (http://ngds-ku.org/kamal), Former Senior Scientific Officer, Control-Systems Laboratories and Consultant, Guidance, Navigation and Control Laboratories, both at SUPARCO (Plant), Pakistan Space and Upper Atmosphere Research Commission, Visiting Faculty, Department of Aeronautics and Astronautics, Institute of Space Technology, Islamabad; Professor and Chairman, Department of Mathematics, University of Karachi, Karachi 75270, Pakistan; *Telephone***:** +92 21 9926 1300-6 ext. 2293