Mass spectrometric study of planetary atmospheres in future missions: a case study, Venus Neutral and Ion Mass Analyzer (VENIMA).

R. R. Mahajan[1], S. K. Goyal[1], N. Upadhyay[1], A. Auknoor[1], P. Sharma[1], J. Kaur[1], Varun Sheel[1], A. Bhardwaj[1], J. Rami[2] and SAC team. [1]Physical Research Laboratory, Ahmedabad, 380009, India, [2]Space Application Centre, Ahmedabad, 380015, India. *Email: ramakant@prl.res.in

Introduction: The exploration of Venus continues to be of utmost priority for planetary scientists to quench their thirst for comparative assessment of terrestrial planets. The Pioneer Orbiter missions by NASA [1] and the Venera orbiter/lander missions [2] by Lavochkin (Soviet Union) flew about 30 years ago. In the last couple of decades, Venus has only been studied through flyby missions and orbiters such as Venus Express and Akatsuki. Venus is categorized as an arid planet through the data from early missions. The majority of its atmosphere is largely unknown. The greenhouse effects cater to the formation of a 25 km thick cloud layer composed of sulphuric acid derivatives. The search for similarities between Earth, Mars and Venus is still on. Understanding Venus will help us answer the question of how Earth, with a habitable environment, may evolve to become a desiccated planet like Venus in the future [3, 4, 5, 6]. Determination of atmospheric composition through in-situ measurements is required for understanding the role of chemistry in various processes that took place to shape present day structure.

Discussion: The VEnus Neutral and Ion Mass Analyser (VENIMA) is based on the concept of quadrupole mass spectrometer (Mass range: 2 – 200 amu and mass resolution {M/ΔM} >10). The incoming sample of gaseous species is filtered based on the ratio of their mass to their charge (m/q). VENIMA can be programmed to either sweep across a range of (m/q) ratios or allow only a species of interest to pass, by tuning the instrument to a fixed (m/q). It can be optimized for an orbiter mission as well as an atmospheric flight (atmospheric entry on board a nano-sat or balloon). The instrument shall employ a faraday-cup and a channeltron-electron multiplier as detectors. VENIMA shall function in two different modes *viz.* a) The Neutral Mode, which is used to measure neutral species by passing them through an ionizer, and b) The Ion mode, which is used to measure the positively-charged ambient ions. VENIMA will effectively characterize the neutral gases and ambient ions by measuring the isotopic and molecular compositions of the Venus' upper atmosphere and ionosphere. These compositional measurements are required to understand the effect of interplanetary plasma and electromagnetic fields on the Venusian atmosphere.

Measurement of chemical compositions of the upper and middle atmospheric regions to verify against the models of primordial accretion, measurement of vertical and sectoral variations in the chemical composition of the Venusian atmosphere, estimation of atmospheric loss and measurement of isotopes to determine the early evolution of Venus are some of the objectives that we hope to achieve through our investigations with VENIMA instrument.

References: [1]. Colin L. (1997) Pioneer venus missions. In: Encyclopedia of Planetary Science. Encyclopedia of Earth Science. Springer, Dordrecht. https://doi.org/10.1007/1-4020-4520-4_30. [2]. Vaisberg O.L. (1997) Venera missions. In: Encyclopedia of Planetary Science. Encyclopedia of Earth Science. Springer, Dordrecht. https://doi.org/10.1007/1-4020-4520-4_435. [3]. National Research Council. (2003). *New Frontiers in the Solar System: An Integrated Exploration Strategy*. National Academies Press. [4]. Board, S. S., & National Research Council. (2012). *Vision and voyages for planetary science in the decade 2013-2022*. National Academies Press. [5]. VEXAG, N., Banes, K., Bullock, M., Chin, G., Grim, B., Keifer, W., ... & Tsang, C. (2016). Goals, Objectives, and Investigations for Venus Exploration. *Online at http://www. lpi. usra. edu/vexag (1 Sept. 2020)*. [6]. Glaze, L. S., & Garvin, J. B. (2018). Exploring Venus: Never Give Up, Never Surrender. *LPI*, (2083), 2024.