Upper Atmospheric Investigations using Radio and Optical Techniques

A THESIS

submitted for the award of Ph.D degree of MOHANLAL SUKHADIA UNIVERSITY

 $in \ the$

Faculty of Science

by

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Under the Supervision of

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to

the memory of my father

DECLARATION

I Mr. Sumanta Sarkhel, S/o (Late) Mr. Sukumar Sarkhel, resident of A-001, PRL residences, Navrangpura, Ahmedabad 380009, hereby declare that the work incorporated in the present thesis entitled, "Upper Atmospheric Investigations using Radio and Optical Techniques" is my own and original. This work (in part or in full) has not been submitted to any University for the award of a Degree or a Diploma.

Date :

(Sumanta Sarkhel)

CERTIFICATE

I feel great pleasure in certifying that the thesis entitled, "Upper Atmospheric Investigations using Radio and Optical Techniques" embodies a record of the results of investigations carried out by Mr. Sumanta Sarkhel under my guidance.

He has completed the following requirements as per Ph.D. regulations of the University

(a) Course work as per the university rules.

(b) Residential requirements of the university.

(c) Presented his work in the departmental committee.

(d) Published minimum of two research papers in a referred research journal.

I am satisfied with the analysis of data, interpretation of results and conclusions drawn.

I recommend the submission of thesis.

Date :

Ramanathan Sekar Professor (Thesis Supervisor)

Countersigned by Head of the Department

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List of Publications

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- Simultaneous sodium airglow and lidar measurements over India: a case study, S. Sarkhel, R. Sekar, D. Chakrabarty, R. Narayanan, and S. Sridharan, J. Geophys. Res., 114, A10317, doi:10.1029/2009JA014379, 2009.
- A Case Study on the Possible Altitude-Dependent Effects of Collisions on Sodium Airglow Emission, S. Sarkhel, R. Sekar, D. Chakrabarty, and S. Sridharan, J. Geophys. Res., 115, A10306, doi: 10.1029/2010JA015251, 2010.
- A Review on the Na Airglow Mechanism using Simultaneous Na Airglow and Na Lidar Measurements over India, R. Sekar, S. Sarkhel, and D. Chakrabarty, Asian J. Phys., in press, 2010.
- Mesospheric Gravity Waves over Indian Low Latitude Stations using Sodium Airglow Measurements, S. Sarkhel, R. Sekar, D. Chakrabarty, and R. Narayanan, *To be communicated*, 2010.

Papers Presented in National/International Conferences

- Attended International School on Atmospheric Radar (ISAR-NCU 2006), Chung-Li, Taiwan and delivered a talk entitled "Mesosphere-lower ionosphere investigations using Indian MST radar and optical techniques."
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- Presented a paper entitled "Sodium Airglow Observations from India" by S. Sarkhel, R. Sekar, D. Chakrabarty, R. Narayanan, and S. Sridharan in AOGS 2010, Hyderabad, India.
- Presented a paper entitled "Mesospheric Gravity Waves over Indian Regions using Sodium Airglow Measurements" by S. Sarkhel, R. Sekar, D. Chakrabarty, and R. Narayanan in COSPAR 2010, Bremen, Germany.

Abstract

The present thesis work comprises of the investigations of upper atmosphere using narrow-band airglow photometers, sodium (Na) lidar, radars and satellite-borne instruments. Coordinated observations using Na airglow photometers and Na lidar were obtained from Gadanki (13.5°N, 79.2°E) during March, 2007 which were supplemented by altitude profiles of ozone concentration and temperature obtained from SABER instrument on board TIMED satellite. A case study shows that the measured average airglow intensity on one night (20 March, 2007) is less as compared to the next night despite Na atom concentration being large. Detailed analyses reveal that collisional quenching process was responsible for the reduced airglow intensity on 20 March as, atmospheric pressure at mesospheric height on that night was found to be larger compared to the next night. Further, on a given night, it was observed that Na airglow intensity variation matches fairly well with the Na atom concentration at an altitude situated at around one scale height above the altitude of maximum Na atom concentration. The analyses suggest that the altitude variation of the collisional quenching needs to be considered to account for the observed Na airglow intensity variation.

Systematic measurements using Na airglow photometers were carried out from Mt. Abu (24.6° N, 72.7° E) and Gadanki during cloudless and moonless nights of winter and equinoctial months during 2006-2009 in order to derive the periodicities of gravity waves. The analyses using mesospheric temperature and horizontal wind, obtained from TIMED and TIDI onboard TIMED satellite, nearly over both the places reveal the occurrence of convective and dynamical instabilities within Na airglow layer on a few occasions. The power spectra of Na airglow intensity variations indicate that the dominant periods, on those observational nights are significantly less in comparison with the cases where the instabilities occurred much beyond the Na airglow layer suggesting the possibility of breaking of gravity waves into smaller-scale sizes in the former cases.

Some of these of gravity wave modes penetrate through the mesopause layer and reach thermosphere-ionosphere system. These gravity waves may act as a seed perturbation to generate plasma bubbles during post sunset hours which evolve in space and time. During post mid-night hours, these plasma bubbles become nonevolutionary and drift with the background wind and are known as fossil bubbles. However, on a few occasions, these may be observed to be reactivated by the neutral winds and can be captured by coordinated VHF radar and 630.0 nm airglow photometric measurements. One such case in support of this proposition is reported in the present thesis.

Keywords

Sodium Atom, Sodium Airglow, Mesosphere, Collisional Quenching, Mesopause, Gravity Waves, Convective and Dynamical Instabilities, Equatorial Spread F, Active Fossil Bubble

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