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RESEARCH NEWS

'FIP-effect' in the solar and stellar coronae

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There is currently a great controversy raging over the element abundance variation in both solar and stellar coronae. Reviews[1,2] of direct extreme ultraviolet (EUV) and X-ray studies of the solar corona indicate that the abundances of elements with low First Ionization Potential (FIP) < 10 eV (e.g., Fe, Mg, Si, Ca) are enhanced in the solar corona relative to their abundances in the photosphere by factors of 3 to 10. The abundances of species with high FIP > 10 eV (e.g., O, Ne, Ar) generally appear to be the same in the solar photosphere and corona. This phenomenon is known as the 'FIP-effect', but there is not yet any widely accepted model to explain it. The FIP-dependent variation has also been shown from solar wind and spectroscopic studies. Abundance anomalies, such as the 'FIP-effect', can have important consequences for the radiative loss functions and might provide new and potentially powerful diagnostics for the physical processes in the outer atmospheres of the Sun and other stars.

With the launch of ROSAT Wide Field Camera (WFC) and subsequently the Extreme Ultraviolet Explorer (EUVE), astronomers have had their first consistent access to the EUV waveband (100–1000 Å) to observe sources outside the solar system. Data from the ROSAT EUV sky surveys have allowed study of the global properties of white-dwarfs, coronally active stars and cataclysmic binaries. The possible presence of the so-called 'FIP-effect' from the EUVE data is indicated in some stellar coronae (e.g., α Cen, ε Eri) but not in others (Procyon, for instance)[3]. Most numerous group of EUV sources, the active cool stars and the study of their coronae have been carried out with EUVE satellite. With a resolution of about 1 Å, EUVE has offered a unique opportunity to study individual spectral lines in stellar EUV spectra. This has allowed major advances in the field, such as the derivation of detailed emission measure distributions for the temperature range of log T ~ 5–7.5 K; and the inference of plasma densities from density-sensitive line ratios. EUVE observations coupled with IUE (International Ultraviolet Explorer) or HST (Hubble Space Telescope), have made it possible to study the temperature structure of the outer atmospheres of stars, from the chromosphere and the transition region up through to the corona. This is necessary to calculate the atmospheric energy balance, to identify and test possible heating mechanisms.

Abundance anomaly in the Sun and Procyon, whose coronae look superficially similar, has recently been investigated[4]. Using the same lines and the same atomic data, it could not be explained why the Sun exhibits a 'FIP-effect' but Procyon does not. It may be argued that the reality of the 'FIP-effect', even in the Sun, may be an artifact of the spectral lines chosen for the abundance analyses. However, if the same lines and the same atomic data are used, it would be difficult to imagine a situation wherein errors in the atomic data also depended on FIP, such that when analysing solar EUV and X-ray spectra it would always give rise to the 'FIP-effect'. Other controversies regarding earlier solar results, such as whether the assumptions of ionization equilibrium might not be applicable in some circumstances and gives rise to spurious abundance anomalies, call for detailed interesting investigation.

Consequently it appears that, while study of coronal EUVE data is very important, there is a ground for debate why the Sun exhibits 'FIP-effect'. Thus, the study of coronal abundances promises to be an interesting field of research with space programs with high-resolution EUV capabilities, such as the SOHO satellite-borne CDS and SUMER instruments. Based on our own research[5], making use of high-FIP coronal spectral lines (Ne VI: 999.6 and 1006.1 Å) to low-FIP ones (Mg VI: 1190.07 and 1191.62 Å), an important observing sequence has been planned by the SUMER team[6] for further studies on this topic. Meanwhile, the absence of the 'FIP-effect' in the corona of Procyon provides evidence that the 'FIP-effect' is not a ubiquitous signature of late-type stellar coronae. The available solar observations, however, provide a compelling body of evidence[2] that the 'FIP-effect' is operative in the solar atmosphere.

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SCIENTIFIC CORRESPONDENCE

Rejuvenating our rivers – The *Akshaydhara* concept

With increasing population and urbanization, it is becoming clear that there is a need to evolve a development strategy that ensures providing the current requirements of resources without compromising the sustainability and growth of future generations. With this perspective, as one looks for solutions to the present-day problems, one often comes to the realization that some of our development policies and practices, particularly concerning water resource management, have not blended with our socio-economic and hydrometeorological constraints. In our opinion, the present practice of wastewater disposal, whether treated or untreated, into surface water bodies is not suited to our country. This practice is flawed for the following reasons:

i) In our country, a very large section of the population, both in rural and urban areas, uses raw water from surface water bodies for human consumption. The secondary treated sewage water can contain up to 20,000 *E. coli* bacteria/100 ml of water that, even when diluted several times in the receiving body, is more than the safe limit for drinking water.

ii) In actual practice, local municipal bodies as well as industries discharge largely untreated wastewater into the surface water bodies, namely rivers, streams, lakes, etc. This practice is largely responsible for fouling up of a large number of surface water bodies including the revered Ganga and other major rivers.

iii) The rainfall is highly seasonal in large parts of our country, and occurs over a short rainy season with a very long (almost three fourth of the year) dry period. As a result, rivers and lakes naturally experience progressive decrease and sluggishness in their flow soon after rainy season. This causes progressive decrease in the self-purification capacity of surface water bodies during the course of a year. Therefore, with the approach of summer season, whereas the wastewater volume increases, the diluting volume decreases, leading to progressive increase in the fouling up of rivers and lakes.

iv) Compounding the problem further is overall increase in wastewater generation due to (a) increased population, (b) increased urbanization, (c) increased industralization, and (d) increasing backlog of creating and maintaining costly sewerage systems and treatment facilities.

v) Increased population has also necessitated higher agricultural production. The largest increase in food production in the country has come about as a result of the green revolution from regions where irrigated agriculture/horticulture has been possible.

vi) Increased abstraction of surface water for domestic, irrigation as well as industrial applications has also contributed directly to dwindling of flow in river courses.

vii) Large-scale exploitation of groundwater for a variety of uses and a consequent lowering of groundwater levels over the years has also contributed to decrease in the river discharge due to reduction in effluent groundwater discharge making up the base flow component.

Thus, a combination of several factors has resulted in dwindling of river flows and the present state of decay of our rivers and other surface water bodies. With progressive increase in economic activity, use of water and resulting generation of wastewater is bound to increase and the problem of degradation of rivers can only become worse unless the base flow can be rejuvenated. This can only be achieved by artificially enhancing the recharge of water to shallow aquifers.

Artificial recharge of groundwater, however, requires two things: (i) surplus water of reasonable quality for which there may be no immediate use and; (ii) an appropriate technology for recharging this water. In our context, one can only think of two sources that may be termed as surplus and may be available for recharging of groundwater substantially. These are: (i) domestic wastewater – a year round dependable source amenable to renovation through an appropriate scheme and; (ii) storm water – essentially a source of nuisance for populated areas due to temporary flooding and disruption of civic life. In addition, the industrial wastewater, once pre-treated to meet existing pollution control standards, can be allowed to supplement the domestic effluent for recharging.

Domestic wastewater may be further sub-divided into two components; (i) the sanitary component, comprising of toilet waste and (ii) the non-sanitary component comprising of wastewater originating from kitchen, bathing, washing, etc. This non-sanitary component of wastewater is more than 70% of the total amount of sewage generated and is much less dangerous than the sanitary component that contains harmful pathogens. The two components of wastewater are carried by separate drains in the prevailing practice of building construction but are mixed subsequently outside the house into a common sewer. Therefore, if we are to