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# ABSTRACTS OF ORAL PRESENTATIONS

## JUPITER'S IO TORUS VIEWED AS A NEBULA

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Space physics research often involves studies of the behavior of plasma and magnetic field structures on a scale large enough to justify the claim that physical understanding, if generalized, apply to astrophysical processes. The availability of rockets to carry scientific payloads throughout the solar system has done for space physics what the introduction of the telescope did for astronomy. The capability to make *in situ* measurements has made all the difference. We now know what we are looking at.

The plasma torus surrounding Jupiter and associated with its innermost Galilean satellite Io is a good example. The Jupiter flybys by several spacecraft revealed that Io is covered with volcanoes that injected about 1000 kg $s^{-1}$ of sulfur dioxide and its constituents into an Io-like orbit about Jupiter whereupon the gas became ionized to form a relatively dense ($10^3$ – $10^4$ ions $cm^{-3}$) torus of ionized sulfur and oxygen. The cross-sectional diameter of the torus is about the size of Jupiter, and its overall outer diameter ($1 \times 10^{11}$ cm) makes it almost as large as the Sun ($1.5 \times 10^{11}$ cm).

The torus itself is dynamic. It radiates approximately $3 \times 10^{12}$ Watts in the extreme UV (mainly 685 Å). The radiation is stimulated by impact from the high-energy tail of a thermalized 3 eV (rms) electron population in the torus. The ion thermal temperature is about 50 eV. The radiative loss rate from the torus is so large that the torus would dim perceptibly in just two hours if the electrons were not resupplied with energy almost continuously. Within the torus there are sharp temperature gradients and an outstanding ribbon-like feature. Finally, the torus and its sharp, dense ribbon oscillate in the plane of the torus with an amplitude of nearly 1 $R_J$ and a period that is synchronized to System III period (the spin period of Jupiter's tilted magnetic dipole. The motion can be explained by the presence of a 30 MV electric potential of 30 MV across Jupiter's magnetospheric tail. Few of these phenomena are well understood.

It must be agreed that unless we can get a firm grip on the physics of the Io torus, it will be even more difficult to understand distant astrophysical nebula that are seen exclusively by remote sensing.

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## TEMPERATURE AND DENSITY FLUCTUATIONS IN PLANETARY NEBULAE

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There are several issues in the abundance determinations in gaseous nebulae that have been present now for several years: (a) the $T_e$ derived are systematically different for different line ratios, and (b) the intensity of the λ4267 line of $C^{++}$is systematically larger than expected from the λ1909 line, and the derived abundance of $C^{++}$ is larger for I(4267)/I(Hβ) than for I(1909)/I(Hβ). In recent times the faint recombination lines of $O^{++}$ have become available for some bright PNe and this problem was analyzed by Mathis, Torres-Peimbert, & Peimbert (1998); some of their results are presented here.

Since Peimbert (1967) proposed a scheme to study the temperature inhomogeneities

$$T_0 = \frac{\int T N_e N_i dV}{\int N_e N_i dV} \quad \text{and} \quad t^2 = \frac{\int (T-T_0)^2 N_e N_i dV}{\int T_0^2 N_e N_i dV} ,$$

where assuming a smooth temperature distribution it is possible to obtain $T_0$ and $t^2$ from the observed ratio of lines of the same ion that originate in different upper states. This treatment has not been widely accepted given that it is cumbersome, it assumes a smooth temperature distribution, and in general it has yielded larger values for $t^2$ than predicted by many ionization structure models.

We studied the possibility of a bimodal temperature distribution $T_{hi}$ and $T_{low}$, and a fraction $f_{hi}$

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and $f_{low}$ of volumes occupied by this material, such that $f_{hi} + f_{low} = 1$; furthermore they studied the possibility of having this bimodal medium at different densities. The range of temperatures used was $6500 \leq T_e \leq 35000$, and the range of densities $10^4 \leq N_e \leq 10^6$.

From a comparison with a sample of PNe we found the following results: (A) $O^{++}/H^+$ derived from recombination lines is × 2.7 that form forbidden λ5007. (B) $(C^{++}/O^{++})_{rec}$ and $(C^{++}/O^{++})_{UV}$ agree. The mean value of $\langle X \rangle = 0.88$. (C) In most PNe the observed line strength ratios require a wide distribution of temperature and densities. However there might be unexplained temperature fluctuations of very dense clumps ($n \leq 10^{5.6}\mathrm{cm}^{-3}$) ionized to $O^{++}$ and contributing $\geq 10\%$ of the emission measure from $O^{++}$

Mathis, J. S., Torres-Peimbert, S.. & Peimbert, M. 1998, ApJ, in press

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## MODELS OF COMPACT H II REGIONS

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Compact H II regions are thought to be produced by recently formed O and early B type stars still embedded in their parent cloud. They are usually found in groups and are characterized by electron densities in the range $\sim 10^3 - 10^4$ cm$^{-3}$, sizes 0.05 – 0.3 pc, and emission measures $\sim 10^7$ pc cm$^{-6}$ (e.g., Wood & Churchwell 1989; Garay et al. 1993; Kurtz, Churchwell, & Wood 1994). The overpressure of the H II regions makes them expand into the natal cloud. Using the classical model of the evolution of H II regions (e.g., Spitzer 1978), a region of ionized gas excited by an O7 star, born in a medium with a constant ambient density of $10^5$ cm$^{-3}$, would have expanded to a radius of 0.1 pc after only $\sim 10^4$ years. Then, the small sizes of the compact H II regions would imply that they are very young objects, with lifetimes $\sim 10^4$ years. In an ambient medium with a density gradient the evolution of the H II regions can be even faster (e.g., Franco, Tenorio-Tagle, & Bodenheimer 1989, 1990). Wood & Churchwell (1989) found, however, that there are too many compact and ultracompact (diameters $< 0.05$ pc) H II regions to be consistent with their short dynamical ages. They concluded that the expansion of these H II regions is inhibited by some mechanism, so that their small sizes do not necessarily indicate that they are extremely young. Several suggestions have been made to explain the large discrepancy between the observed number of compact and UCHII regions and the number expected from the formation rate of massive stars and the time they spend in this compact phase (cf., Churchwell 1990).

In this review we discuss the current models proposed to lengthen this compact phase. These models involve bow shocks (Van Buren et al. 1990), the photoevaporation of disks around massive stars (Hollenbach et al. 1994), high density molecular cores (DePree, Rodríguez, & Goss 1995), and mass loaded stellar winds (e.g., Lizano et al. 1996; Dyson, Williams, & Redman 1996).

Finally, we note that the observed excess number of compact and ultracompact H II regions has stimulated theoretical research on physical mechanisms that could lengthen this compact phase. Probably all or a combination of these mechanisms occur in nature. The observational challenge is now to prove or discard the proposed models.

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## NOVAE AND BAL QSO'S: THE ALUMINUM TEST

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Broad absorption lines (BALs) caused by rapidly ($\lesssim$ 30 000 km s$^{-1}$) outflowing gas are seen in the spectra of $\sim$ 10% of radio quiet QSOs (Weymann et al. 1991). Analysis of the derived column densities has led to reported abundances of C, N, O, Si, and sometimes other elements, that are 1 to 2 orders of magnitude greater than solar (Turnshek et al. 1996, and references therein). An especially high abundance of phosphorus, P/C $\approx 65\ (\mathrm{P/C})_\odot$, was reported by Junkkarinen et al. (1995). Shields (1996) proposed that the BAL gas largely consists of debris of nova explosions occurring in the inner few light years of the QSO nucleus. This is motivated by high phosphorus abundances in the ejecta of model novae (Politano et al. 1995) and by the resemblance of C, N, O, and Si abundances in observed "neon nova" shells to those in BAL QSOs. The needed rate of novae could occur in a nuclear star cluster of mass $\sim 10^8\ M_\odot$, in which single white dwarfs accrete hydrogen by means of repeated orbital passages through an accretion disk around a supermassive black hole.

Nova models predict enhanced abundances of odd numbered elements, relative to neighboring even numbered elements; and high Al is observed in nova debris (Andreä et al. 1994). Al III λ1857 is seen both in BAL and broad emission-line (BEL) spectra. This offers a potential test of novae as a source of BAL gas

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