Phosphorous chemistry in the shocked region L1157 B1

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Since shock waves are ubiquitous in interstellar space, a thorough understanding of shock chemistry is important to interpret observed chemical composition. This is particularly true for star-forming regions. For example, outflow gases from protostar bring on shock waves due to collision with surrounding gases.

L1157 dark cloud harbors a low-luminosity Class 0 protostar, which drives a well-collimated molecular outflow. L1157 B1 is a shocked region formed by an interaction between the molecular outflow and ambient gas. Since the B1 position is spatially apart from the protostar, the "pure" shock chemistry can be investigated. Because of this reason, many observational studies are conducted to investigate physical and chemical condition [1] [2] .

Very recently, Yamaguchi et al. (2011) reported detection of PN for the first time in the L1157 B1 and B2 shocked region. The abundance relative to H_2 is estimated to be n(PN)/n(H2) = (2-6) × 10^{-10} towards B1 and (3-7) × 10^{-10} towards B2 [3]. More recently, a subsequent work (Yamaguchi et al. in prep) reported that PO is not detected at shocked region; the upper limit of PO abundance relative to H_2 is 2.5 × 10^{-10} . Chemistry of P-bearing species has been investigated in the pseudo-time dependent model. For example, Charnley & Millar (1994) investigated P-chemistry in the hot core model, in which they assumed a constant warm temperature (100K-300K) and high density (2.0 ×10^7 cm^{-3}) , and showed that PN can be produced enough to be observed [4]. But shock chemistry calculations that especially focus on p-bearing species have not been conducted.

In this work, we study the evolution of the P-bearing species in a 1D C-shock model. Temporal variations of physical parameters (density and temperature) are adopted from Jimenez-Serra et al. (2008) [5]. We found that observed abundance of PN can be reproduced in a C-shock model with v=20km s^{-1}, n=2.0 × 10^4 cm^{-3} , only if the N atom abundance is high(n(PN)/n(H) ~ 10^{-5}) in the pre-shock gas.

References

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