LETTERS TO PROGRESS IN PHYSICS

Commentary on the Liquid Metallic Hydrogen Model of the Sun III. Insight into Solar Lithium Abundances

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The apparent depletion of lithium represents one of the greatest challenges to modern gaseous solar models. As a result, lithium has been hypothesized to undergo nuclear burning deep within the Sun. Conversely, extremely low lithium abundances can be easily accounted for within the liquid metallic hydrogen model, as lithium has been hypothesized to greatly stabilize the formation of metallic hydrogen (E. Zurek et al. A little bit of lithium does a lot for hydrogen. *Proc. Nat. Acad. Sci. USA*, 2009, v. 106, no. 42, 17640–17643). Hence, the abundances of lithium on the solar surface can be explained, not by requiring the nuclear burning of this element, but rather, by suggesting that the Sun is retaining lithium within the solar body in order to help stabilize its liquid metallic hydrogen lattice. Unlike lithium, many of the other elements synthesized within the Sun should experience powerful lattice exclusionary forces as they are driven out of the intercalate regions between the layered liquid metallic hydrogen hexagonal planes (Robitaille J.C. and Robitaille P.M. Liquid Metallic Hydrogen III. Intercalation and Lattice Exclusion Versus Gravitational Settling and Their Consequences Relative to Internal Structure, Surface Activity, and Solar Winds in the Sun. *Progr. Phys*., 2013, v. 2, in press). As for lithium, its stabilizing role within the solar interior helps to account for the lack of this element on the surface of the Sun.

As the laws of a liquid are different from those of a gas, a liquid star will behave differently from a gaseous star, and before we can predict the behaviour of a star we must know the state of the matter composing it.

James Hopwood Jeans, 1928 [1]

Solar lithium abundance [2], as determined at the photospheric level, are reduced ~140 fold when compared to meteorites [3]. Such a paucity of lithium has presented a challenge for the gaseous models of the stars, as they attempt to account for the relative absence of this element on the solar surface [2,3]. Consequently, solar scientists hypothesized that lithium is being burned deep within the convection zone [2,3]. Lithium is thought to be easily destroyed [^{7}Li(p,α)^{4}He] at temperatures above 2.6 x 10^6 K [4]. Mild mixing of lithium also helps to account for the surface depletion [4–6]. In this regard, it has been postulated that *"stars that host planets experience more mixing in their internal environment"* [7]. As a result, those who adhere to the gaseous models have proposed that greater lithium depletion occurs in stars that have orbiting planets [8], although such claims have been refuted [9]. Nonetheless, such works [7, 9] highlight the significance of the solar lithium abundance problem in astrophysics. In this regard, solar lithium abundances might be better understood within the context of the liquid metallic hydrogen model of the Sun [10–13].

Along with Neil Ashcroft, Eva Zurek and her coworkers recently advanced [14] that lithium could greatly stabilize the formation of metallic hydrogen [15, 16]. This finding has tremendous implication relative to understanding the fate of lithium within the Sun, if indeed, the solar matrix is comprised of liquid metallic hydrogen [10–13].

When the Sun was hypothesized to be built from liquid metallic hydrogen, it was important that the resulting lattice adopt a layered structure similar to graphite in order to properly account for thermal emission [11]. Thus, it was fortunate that Wigner and Huntington [15] had said that metallic hydrogen could exist in a layered lattice resembling graphite. At the same time, since graphite was known to form intercalation compounds, the extension of such chemistry to the layered form of metallic hydrogen proved natural [13]. Therefore, it was thought that the Sun would maintain the integrity of its layered hexagonal hydrogen lattice and associated conduction bands, by permitting non-hydrogen elements to reside within intercalation zones [13]. In addition, since the intercalation compounds of graphite are known to undergo exfoliative processes wherein intercalate atoms are driven out of the graphitic structure, the same mechanism was applied to the Sun [13]. Solar activity became linked to lattice exclusion and the associated expulsion of non-hydrogen atoms from the solar interior [13]. Nonetheless, it was already recognized [11] that lithium should stabilize the metallic hydrogen lattice. As a result, unlike the case for most elements, the Sun should not be working to expel lithium. Such a scenario elegantly accounts for the significant reductions in lithium abundances observed on the surface of the Sun while, at the same time, permitting elevated lithium levels in meteorites, or other objects, which have been first synthesized within the stars. Conversely, the idea that lithium is being burned preferentially within the stars, as proposed by the gaseous models, makes it difficult to account for elevated lithium levels elsewhere in the astrophysical world. Herein lies the merit of sequestering lithium within the solar body and permitting it to participate in nuclear reactions, without preferential burning, in the context of the liquid metallic hydrogen model [10–13].

Dedication

This work is dedicated to my youngest son, Luc.

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