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ABSTRACT

Just notes, not abstract: I rechecked the V339 Del sl but still can't find any obvious lithium lines in the range of 6680Å-6720Å. Based on Tajitsu et al. (2015), they claimed they detected beryllium, ^{7}Be, in the near-ultraviolet spectra of the classical nova V339 Del from 38 to 48 days after the explosion. Since there is no data in the uv range, I checked the record number (7 and 8) around 90 days after the explosion(record 0) because ^{7}Be decays to form ^{7}Li with a half-life of 53.2 days, but I still can't find any lithium absorption lines. HOWEVER, I did find potential blue-shifted lithium lines only in records 1 and 2.

1. INTRODUCTION

Big Bang Nucleosynthesis(BBN) produced the universe's first lithium within roughly 3 minutes after the Big Bang(see Figure 1.), and according to the models from Cyburt et al. (2015), this same process also produce light nuclei such as ^{3}He, ^{4}He, with only a trace amount of lithium. The Cameron-Fowler mechanism is the process by which stars produce ^{7}Li(Cameron & Fowler 1971), at high temperatures (typically T $> 10^7$ K), ^{3}He and ^{4}He nuclei fuse via the reaction

$$^3\mathrm{He} + \alpha \rightarrow {}^7\mathrm{Be} + \gamma$$

For ^{7}Li to be produced, the ^{7}Be nucleus must be transported from the stellar interior to cooler outer layers before it is destroyed by proton captures (Ventura & D'Antona 2009). This transport occurs through convective mixing in stars (such as Asymptotic giant branch stars) undergoing hot bottom burning (HBB), where the large-scale convection currents circulate material in a continuous loop. The ^{7}Be nuclei produced in the hot (T $> 10^7$ K) hydrogen-burning shell are surrounded by these currents and carried outward to the stellar surface via the loop(Cameron & Fowler 1971). Upon reaching the cooler (T $< 10^6$ K) temperature of the envelope, the destructive proton-capture reaction decreases and ^{7}Be can undergo electron capture, decaying into ^{7}Li via Eqn 1 with the emission of a 0.86 MeV neutrino (Izzo et al. 2015).

The lithium seen in very old, metal-poor stars reflects that primordial level and only acts as a baseline for galactic chemical evolution, younger stars show roughly three times more lithium than that value (Fields et al. 2019), which implies that other astrophysical processes must have produced additional lithium

Several production sites have been proposed to explain this excess. Classical novae are now considered a major contributor since the explosive hydrogen burning on the surface of accreting white dwarfs can efficiently synthesizes ^{7}Be, which later decays to ^{7}Li (Tajitsu et al. 2015; Izzo et al. 2015; Cescutti & Molaro 2018). Cosmic-ray spallation also produces lithium when high-energy protons and α-particles collide with interstellar C, N, and O nuclei (Meneguzzi et al. 1971). Asymptotic Giant Branch (AGB) stars may also contribute to Galactic lithium enrichment through the Cameron–Fowler mechanism operating during HBB(Ventura & D'Antona 2009).

1.1. *Asymptotic giant branch (AGB) stars*

AGB stars can produce lithium through processes such as proton ingestion events (PIEs) and HBB. PIEs are triggered when the convective zone generated by a thermal pulse extends into the hydrogen rich envelope, and protons then got transported downward into the hot helium burning regions(Choplin et al. 2022), the new ingested protons undergo rapid nuclear reactions, leading to the production of ^{7}Li via Cameron-Fowler mechanism. In low-mass AGB stars (1–3 $M_\odot$) PIEs can lead to lithium enrichment with abundances of A(Li) = 3 to 5 while in high-mass AGB stars ($>$3–4$M_\odot$), the base of the convective envelope causes proton-capture reactions due to high temperature, producing lithium via the same chain as Eqn.1. However, recent observational and chemical evolution studies from Borisov et al. (2024) indicate that AGB stars alone cannot account for the meteoritic lithium abundances, and suggest that other sources such as novae are required to explain the observed lithium abundance in the galaxies.

1.2. *Galactic cosmic-ray spallation*

Lithium is synthesized in the interstellar medium when high-energy protons and cosmic rays collide with C, N, O. These collisions cause the target nuclei to expel nucleons and form light elements like lithium, beryllium(Vangioni-Flam et al. 1998; Laumer et al. 1973), this is a primary non-thermal nucleosynthesis pathway for lithium, especially for the isotope ^{6}Li. In a survey for the Small Magellanic Cloud, 'Ciprijanovi'c (2016) stated that galactic cosmic rays could only produce a very small amount of lithium in the Small Magellanic Cloud, with only 0.16% of the measured abundance explained by this source.

1.3. *Classical Novae*

During a classical nova explosion, extreme temperatures ($\sim$100 to 200 million K during the explosion) enable the nuclear reaction $^3\mathrm{He}(\alpha,\gamma)^7\mathrm{Be}$, producing radioactive ^{7}Be. This ^{7}Be is then transported outward in the nova ejecta, and in order to decay into ^{7}Li, ^{7}Be must avoid destruction from further proton captures in the hot remnant before the ejecta thins. As the ejected shell expands and cools over time, the ^{7}Be decays with a half-life of $\sim$53 days, transforming into ^{7}Li via

$$^3\mathrm{He}(\alpha,\gamma)^7\mathrm{Be} \xrightarrow[53\text{ days}]{e^-} {^7\mathrm{Li}} \tag{1}$$

This process proposed by Starrfield et al. (1978) is now recognized as a primary pathway for lithium production in nova explosions. The evidence includes the detection of blue-shifted ^{7}Be II lines in the ultraviolet spectra of several classical novae, such as V339 Del (Tajitsu et al. 2015), V5668 Sgr (Molaro et al. 2016), and V2944 Oph (Tajitsu et al. 2015). The blueshifts confirms the ^{7}Be is indeed in the rapidly outflowing ejecta and not the surrounding medium. A report in 2015 from Izzo et al. (2015) also stated that they directly detected the lithium in the early optical spectra of Nova V1369 Cen(see Figure 2.). The measured lithium abundance in the nova ejecta is significantly higher than solar values, with log abundances of 4.8 relative to sodium, suggesting classical novae are sufficient to explain the observed overabundance of lithium in young stellar populations.

Note that V1369 Cen was a "slow" nova, means it has a slow light curve evolution with a decline time. The slower expansion of the ejecta in classical novae is important because it gives ^{7}Be sufficient time to decay into ^{7}Li before the ejecta becomes too diffuse to observe(Tajitsu et al. 2015; Molaro et al. 2016). The slower radial velocity also results in narrower spectral lines, making the detection of the lithium line easier(Selvelli et al. 2018). In contrast, a "fast" nova, the thin ejecta and very broad spectral lines would make the specific identification of the lithium line far more challenging.

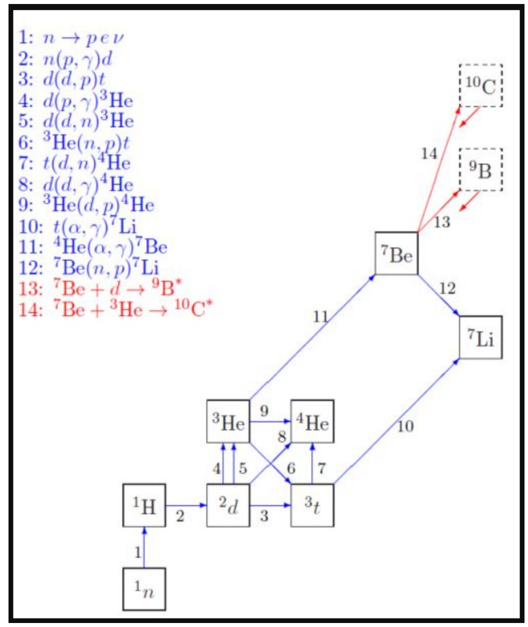

Figure 1. Simplified nucleosynthesis network from Fields (2011), showing pathways for lithium production in both primordial and galactic evolution. The network shows how deuterium starts the reaction chains leading to ^{3}He, ^{4}He, and ultimately to ^{7}Li and ^{7}Be.

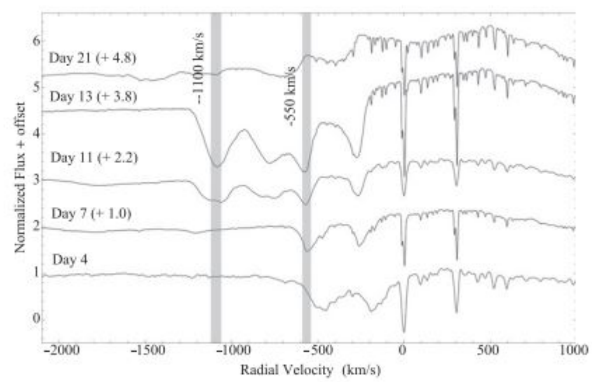

Figure 2. Figure from Izzo et al. (2015), showing identified blueshifted ^{7}Li I λ6708 Å, moving at –550 km/s. Note that the absorption feature is only prominent between days 7 to 13.

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