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The Halo of NGC 2438 revisited

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NGC 2438 is the classical multiple shell or halo planetary nebula (PN). Its central star and the main nebula are well studied. Also, it was target of various hydrodynamic simulations. About a decade ago, this initiated a discussion on whether the halos are mainly containing recombined gas, or if they are still (photo)ionized. The latter might be caused due to filling factor of the main nebula being well below unity. We investigated with a deeper look on morphological details (ray-like structures) and multiple position slit spectra the properties of the outer shell and the halo. Moreover, as the classical diagnostic diagrams (\([\text{S}\ ii] \ 6716/32, \ [\text{O}\ iii] \ 5007/4363, \ etc\).) are not usable at densities below 100 particles per cubic centimetre, we discuss theoretical investigations towards new diagnostic tools and the feasibility of investigating this low density material with optical spectroscopy.
The Halo of NGC 2438 revisited
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Discussion:
As the main nebula and the shell of NGC 2438, due to its position far from the galactic plane and due to the outer shells, is not influenced by ISM interaction, it is a perfect target for this investigation. The line ratios show us hardly any variation in the excitation of the gas between the main nebula and the halo. This leads us to the suggestion, that the small scale clumpiness of old PN (typical filling factor \( \epsilon \approx 0.1 \)) allows a sufficient amount of UV radiation leaking to the halo, to photoionize it. The “recombination” halo postulated by Schönberner & Steffen (2002) by using 1D-hydros \(( \rightarrow \epsilon = 1.0 )\) leads to \( T_e \leq 3\,000\,K \).

Theoretical predictions show line ratios useable for the investigation at densities towards a few particles \( cm^{-3} \). These line ratios, other than for the classical diagnostic diagrams, have to be combined to filter abundance effects and the temperature of the central star. Although the first look showed us lines in our spectra, deeper and redder ([SIII]) spectroscopy is required.

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