Coupling hydrodynamics with comoving frame radiative transfer: II. Stellar wind stratification in the high-mass X-ray binary Vela X-1

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CONTEXT: Vela X-1, a prototypical high mass X-ray binary (HMXB), hosts a neutron star (NS) in a close orbit around an early-B supergiant donor star. Accretion of the donor star's wind onto the NS powers its strong X-ray luminosity. To understand the physics of HMXBs, detailed knowledge about the donor star winds is required.
AIMS: To gain a realistic picture of the donor star in Vela X-1, we constructed a hydrodynamically consistent atmosphere model describing the wind stratification while properly reproducing the observed donor spectrum. To investigate how X-ray illumination affects the stellar wind, we calculated additional models for different X-ray luminosity regimes.
METHODS: We use the recently updated version of the PoWR code to consistently solve the hydrodynamic equation together with the statistical equations and the radiative transfer.
RESULTS: The wind flow in Vela X-1 is driven by ions from various elements with Fe III and S III leading in the outer wind. The model-predicted mass-loss rate is in line with earlier empirical studies. The mass-loss rate is almost unaffected by the presence of the accreting NS in the wind. The terminal wind velocity is confirmed at v_inf â‰ˆ 600 km/s. On the other hand, the wind velocity in the inner region where the NS is located is only â‰ˆ100 km/s, which is not expected on basis of a standard Î²-velocity law. In models with an enhanced level of X-rays, the velocity field in the outer wind can be altered. If the X-ray flux is too high, the acceleration breaks down because the ionization increases.
CONCLUSIONS: Accounting for radiation hydrodynamics, our Vela X-1 donor atmosphere model reveals a low wind speed at the NS location, and it provides quantitative information on wind driving in this important HMXB.

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