Gallium abundances in mercury-manganese stars

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Abstract.

There is a widespread assertion in the literature that the optical Ga lines give much higher abundances than the UV lines. We have determined Ga abundances in HgMn stars taking the observed hyperfine structure of the optical Ga II lines into account. This reduces these abundances to within 0.2 dex of the values from the resonance lines.

Key words: stars: abundances — stars: peculiar

1. Gallium in optical spectra of HgMn stars

Ga II was first identified in HgMn and He-weak stars by Bidelman (1962), who identified four lines in the 4250 - 4260 Å region. The recent studies of gallium in HgMn stars by Keith Smith (1995, 1996) found high overabundances from the UV resonance lines of Ga II and Ga III (between 2 and 4 orders of magnitude). Most curve-of-growth analyses based on the optical lines gave much higher abundances than the UV lines. This difference was greatest for the strongest lines and ranged up to 1 dex in several cases (see Smith 1995, 1996; Takada-Hidai et al. 1986). Several explanations have been suggested (extreme stratification, NLTE line formation, etc). We have tested the hypothesis of Smith that hyperfine structure in the lines might be able to account for this. We used simplified line models based on the laboratory spectroscopy of Bidelman & Corliss (1962) and a theoretical model by Lanz et al. (1993), with *gf*-values from Ryabchikova & Smirnov (1994). Our observations were Lick Hamilton Échelle spectra taken using the CAT in 1994-1997 and AAT service observations. We observed nearly the entire Smith & Dworetsky (1993) sample of HgMn stars. We used the LTE spectrum synthesis code UCLSYN, developed over many years at UCL by MMD and KCS. The code allows us to adjust input abundances, and simulate instrumental profiles, rotation, and binarity.

The ability to allow for contaminating blends is critically important for Ga II. This is shown in the calculations for κ Cnc in Fig. 1 for four blue lines and one red line. The tick marks for Ga are at the positions of the main observed (or computed) hfs components, with lengths roughly proportional to the strengths of the components. Other tick marks indicate the positions of the most important blends. It is immediately apparent that the most severe blends are in λ4262

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(Cr II) and λ6334 (Ne I) and if these are not taken into account one can seriously overestimate the abundance of Ga.

Our results are given in Table 1 and show that the mean difference in abundance is only 0.2 dex when hfs is taken into account along with blends. There is no trend with strength of the lines evident in our results. Much of the difference may be due to the crude model used for hfs. Better laboratory observations are needed to extend this work. Meanwhile we will be checking further using theoretical hfs predictions.

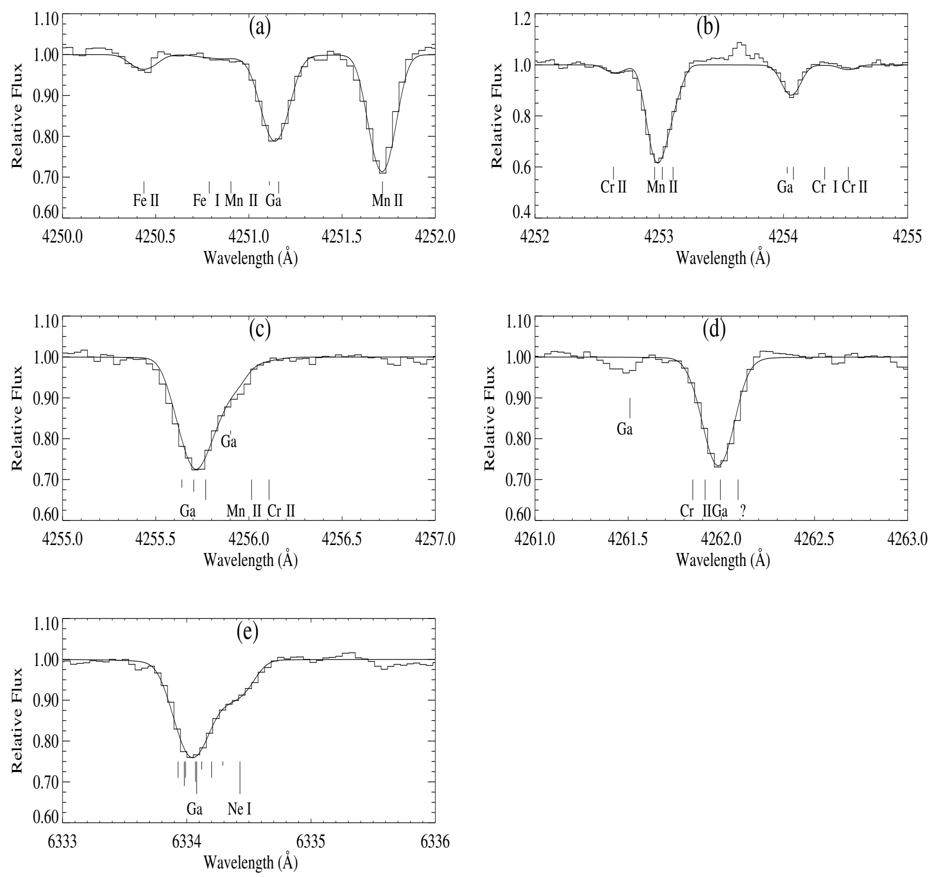

Figure 1. (a) - (e): Observed (histograms) and synthetic (continuous lines) spectra of the Ga II lines λλ4251, 4254, 4255, 4262, and 6334 in the HgMn star κ Cancri.

Table 1. Gallium abundances

Star	Ga II Abundances (log N(H) = 12)					Mean	σ	Pub.
	λ4251	λ4254	λ4255	λ4262	λ6334			UV[a]
87 Psc	5.60	≤6.0	5.55	5.80[b]	5.65	5.65	0.11	5.45
53 Tau	5.55	≤5.7	5.60	5.40[b]	5.82	5.59	0.17	5.65
μ Lep	7.15	7.00	6.75	7.00[b]	6.75	6.93	0.18	6.50
HR 1800	≤4.8	≤4.8	≤4.8	≤4.8	≤5.0	≤4.8	0.09	4.80
33 Gem	5.60	≤5.0	~5.3	≤5.5	≤5.0	≤5.3	0.28	5.20
HR 2676	≤4.3	≤5.0	≤4.3	≤4.7	≤4.0	≤4.5	0.39	4.00
HR 2844	7.18	7.15	6.95	7.00[b]	6.85	7.03	0.14	6.75
κ Cnc	7.00	7.00	6.83	6.70	6.72	6.85	0.15	6.60
36 Lyn	≤6.3	≤6.5	≤5.8	≤5.7	5.80	≤6.0	0.36	5.10
υ Her	6.43	6.32	6.14	6.25[b]	6.20	6.27	0.11	6.05
ϕ Her	6.22	~6.3	5.75	6.10[b]	5.82	6.04	0.24	5.70
28Her	≤4.8	≤6.1	≤4.7	≤5.2	≤5.2	≤5.2	0.55	4.75
HR 6997	6.82	7.00	6.68	6.50	6.40	6.68	0.24	6.45
112 Her	6.62	6.62	6.36	6.38	6.25	6.45	0.17	6.35
HR 7143	6.75	6.81	6.52	6.60[b]	6.51	6.64	0.14	6.35
HR 7361	6.90	6.87	6.66	6.70	6.58	6.74	0.14	6.35
46 Aql	≤4.4	≤5.5	≤4.5	≤4.6	≤4.4	≤4.7	0.47	3.85
HR 7664	5.85	5.90	5.70	5.55	5.60	5.72	0.15	5.60
HR 7775	6.66	6.73	6.38	6.65[b]	5.90	6.46	0.34	6.35
β Scl	6.55	6.70	6.35	6.35[b]	—	6.49	0.17	6.25
$\log(A/A_{\rm vis})$	+0.12	+0.18	−0.09	−0.04	−0.15	—	—	−0.22

[a]Smith (1996); [b]Ga II λ4262 badly blended with Cr II line.

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