

$$(10-b) \quad T^r_r = (\rho + p) g_{rv} u^r u^v - p$$

$$(10-c) \quad T^v_v = (\rho + p) g_{vr} u^v u^r - p$$

$$(10-f) \quad T^v_r = (\rho + p) g_{rv} u^v u^r$$

donde $g_{rv} u^r u^v = g_{vr} u^v u^r = 1/2$ por definición del 4-vector velocidad. De donde obtenemos para T^r_r y T^v_v

$$(10-b-d) \quad T^r_r = T^v_v = \frac{\rho - p}{2}$$

En (10-d) y (10-f) es necesario notar que

$$g_{vr} u^r = u_v, \quad g_{rv} u^v = u_r, \quad \text{y} \quad u^r u^v = g^{rv}$$

Las ecuaciones de Einstein (5) y la expresión (8) para G exigen que $T^r_r = 0$; esta condición sólo puede verificarse si U^r o U_v se anulan, pero ninguna de ambas puede hacerlo ya que por (11) ello significaría la anulación automática de la otra lo que es incompatible con la definición del vector velocidad.

En consecuencia esto contradice la hipótesis de partida, que es suponer la existencia de la forma (4) para una métrica con simetría esférica, y por lo tanto la posibilidad de existencia de un horizonte 4-dimensional.

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A re-analysis of τ Ursae Majoris

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Resumen: Se realiza un nuevo análisis de las estrellas Am τ U Ma utilizando nuevas determinaciones de su temperatura efectiva y gravedad superficial y nuevas medidas de anchos equivalentes e identificaciones de líneas.

Con el método de las curvas de crecimiento se calculan las abundancias de elementos. Se investiga la existencia de ciertos elementos pesados encontrados en las estrellas Ap más frías, especialmente aquellos con Z entre 41 y 55 pero no existe evidencia de ellos. Lo mismo sucede con los elementos más pesados de la tabla periódica.

Introduction

τ U Ma was the first Am star for which a detailed atmospheric analysis was made (Greenstein, 1948; Miczaika et al, 1956). It was studied together with several F stars using equivalent widths and a relative curve of growth method. Greenstein used however an ionization temperature which was too low and he obtained thus a low effective gravity. Subsequent studies of Am stars utilizing model atmospheres have shown however normal gravities (onti, 1965, van't Veer-Monneret, 1963, Provost and van't Veer-Menneret, 1969; Praderie, 1967). Therefore it was thought that a re-analysis of τ U Ma was in time.

Measurements

The measurement of equivalent widths in the range 4000-4860 Å was made upon the microphotometric register of the plates used by Greenstein in his work and loaned generously by him to Dr. C. Jaschek (original dispersion: 2.8 Å/mm at $H\gamma$).

Since Greenstein used only the lines common to all his F stars, a new measurement and identification of all lines was made. An equivalent width-central depth relation was established using the value of the equivalent widths measured by Greenstein; those of the remaining lines were obtained from this relation. The line identification was made using conventional methods. Although a large quantity of lines are affected by strong blends, for the construction of the curves of growth only lines which seemed unblended or very little affected by other contributors were chosen.

TABLA 1

Equivalent widths

For each line is specified: element, multiplet no from Moore (1959), wavelength λ , excitación potential of the lower level, the ordinate of the curve of growth $\log \frac{\omega}{\lambda} \cdot \frac{c}{v}$, the abscissa of the curve of growth $\log \eta$. In the head of each ion a key for the source of the f values and partition functions is given.

| Mult. | $\lambda(\text{\AA}^\circ)$ | $\chi(\text{eV})$ | log gf | $\log \frac{W}{\lambda} \frac{c}{v}$ | log η | Remarks |
|--------------|-----------------------------|-------------------|--------|--------------------------------------|------------|---------|
| Ca I | | | | | | |
| 1 | 4226.73 | 0.00 | -0.55 | +0.73 | +2.16 | a,A |
| 4 | 4425.44 | 1.87 | -0.33 | +0.23 | +0.88 | |
| 4 | 4434.96 | 1.88 | +0.01 | +0.33 | +1.23 | |
| 4 | 4455.89 | 1.89 | -0.54 | +0.30 | +0.67 | |
| 5 | 4283.01 | 1.88 | -0.37 | +0.22 | +0.82 | |
| 5 | 4289.36 | 1.87 | -0.42 | +0.20 | +0.78 | |
| 5 | 4318.65 | 1.89 | -0.15 | +0.23 | +1.03 | |
| 23 | 4578.56 | 2.51 | -0.82 | -0.10 | -0.17 | |
| 23 | 4581.40 | 2.51 | -0.52 | +0.24 | +0.17 | |
| Sc II | | | | | | |
| 15 | 4294.77 | 0.60 | -1.28 | -0.03 | +0.49 | b,A |
| 15 | 4305.72 | 0.59 | -1.22 | +0.29 | +0.60 | |
| 15 | 4314.08 | 0.62 | -0.04 | +0.64 | +1.79 | |
| Ti I | | | | | | |
| 42 | 4535.57 | 0.82 | +0.19 | +0.23 | +1.02 | c,A |
| 42 | 4548.76 | 0.82 | -0.21 | -0.25 | +0.58 | |
| 44 | 4287.40 | 0.83 | -0.17 | -0.32 | +0.58 | |
| 44 | 4290.93 | 0.81 | -0.19 | +0.14 | +0.62 | |
| 44 | 4298.66 | 0.81 | +0.19 | +0.02 | +0.98 | |
| 80 | 4064.20 | 1.05 | -0.50 | +0.05 | +0.07 | |
| 113 | 4453.31 | 1.42 | +0.32 | -0.08 | +0.63 | |
| 113 | 4455.32 | 1.44 | +0.39 | +0.20 | +0.69 | |
| 113 | 4457.43 | 1.45 | +0.46 | +0.27 | +0.76 | |
| 113 | 4482.69 | 1.45 | -0.60 | +0.04 | +0.32 | |
| 145 | 4617.27 | 1.74 | 0.62 | -0.27 | +0.65 | |
| 146 | 4471.24 | 1.73 | 0.05 | +0.17 | +0.11 | |
| 160 | 4463.54 | 1.88 | -0.20 | +0.04 | -0.27 | |
| Ti II | | | | | | |
| 19 | 4395.03 | 1.08 | -0.65 | +0.78 | +2.61 | d,A |
| 19 | 4443.80 | 1.08 | -0.81 | +0.69 | +2.49 | |
| 31 | 4444.56 | 1.11 | -2.37 | +0.40 | +0.92 | |
| 31 | 4468.49 | 1.13 | -0.77 | +0.68 | +2.49 | |
| 31 | 4501.27 | 1.11 | -0.86 | +0.68 | +2.42 | |
| 40 | 4417.72 | 1.16 | -1.37 | +0.62 | +1.86 | |
| 40 | 4464.46 | 1.16 | -2.02 | +0.38 | +1.22 | |
| 40 | 4470.86 | 1.16 | -2.22 | +0.22 | +1.00 | |
| 41 | 4312.86 | 1.18 | -1.37 | +0.61 | +1.84 | |
| 41 | 4330.71 | 1.18 | -2.35 | +0.27 | +0.84 | |
| 50 | 4563.76 | 1.22 | -0.90 | +0.65 | +2.29 | |
| 51 | 4394.06 | 1.22 | -1.93 | +0.45 | +1.26 | |
| 51 | 4399.77 | 1.23 | -1.51 | +0.62 | +1.66 | |

TABLA I (continuación)

| Mult. | $\lambda(\text{\AA}^\circ)$ | $\chi(\text{eV})$ | log gf | $\log \frac{W_c}{\lambda \nu}$ | log η | Remarks |
|-------|-----------------------------|-------------------|--------|--------------------------------|------------|---------|
| 51 | 4418.34 | 1.23 | -2.50 | +0.37 | +0.68 | |
| 61 | 4395.85 | 1.24 | -2.21 | +0.38 | +0.97 | |
| 82 | 4529.46 | 1.56 | -2.15 | +0.60 | +0.76 | |
| 82 | 4549.62 | 1.58 | -0.57 | +0.84 | +2.28 | |
| 82 | 4549.62 | 1.58 | -0.57 | +0.84 | +2.28 | |
| 82 | 4571.97 | 1.56 | -0.65 | +0.84 | +2.22 | |
| 92 | 4779.99 | 2.04 | -1.37 | +0.39 | +1.17 | |
| 92 | 4805.10 | 2.05 | -1.10 | +0.53 | +1.43 | |
| 93 | 4421.95 | 2.05 | -1.67 | +0.29 | +0.81 | |
| 104 | 4367.66 | 2.58 | -1.42 | +0.41 | +0.65 | |
| 104 | 4386.86 | 2.59 | -1.41 | +0.32 | +0.65 | |
| V I | | | | | | |
| 22 | 4379.24 | 0.30 | +0.48 | +0.13 | +0.38 | a,A |
| 22 | 4406.64 | 0.30 | -0.25 | -0.05 | -0.36 | |
| 27 | 4111.78 | 0.30 | +0.45 | +0.13 | +0.33 | |
| Cr I | | | | | | |
| 1 | 4254.35 | 0.00 | +0.30 | +0.72 | +2.97 | e,A |
| 1 | 4274.80 | 0.00 | | +0.68 | | |
| 1 | 4289.72 | 0.00 | | +0.60 | | |
| 10 | 4545.96 | 0.94 | -1.30 | +0.30 | +0.64 | |
| 21 | 4591.39 | 0.96 | | +0.18 | | |
| 21 | 4600.75 | 1.00 | -1.40 | +0.12 | +0.48 | |
| 21 | 4626.19 | 0.96 | -1.40 | +0.18 | +0.52 | |
| 21 | 4652.16 | 1.00 | -1.10 | +0.38 | +0.82 | |
| 22 | 4371.28 | 1.00 | | +0.32 | | |
| 32 | 4648.13 | 2.53 | | +0.07 | | |
| 64 | 4381.11 | 2.70 | | -0.18 | | |
| 81 | 4501.79 | 2.90 | | -0.05 | | |
| 81 | 4622.76 | 2.97 | | -0.12 | | |
| 96 | 4261.35 | 2.90 | | -0.03 | | |
| 96 | 4272.91 | 2.89 | | -0.11 | | |
| 96 | 4319.64 | 2.88 | | -0.22 | | |
| 104 | 4346.83 | 2.97 | | -0.01 | | |
| 127 | 4458.54 | 3.00 | | +0.15 | | |
| 129 | 4411.09 | 3.00 | | +0.18 | | |
| 129 | 4428.50 | 3.00 | | +0.09 | | |
| 145 | 4724.42 | 3.07 | | -0.11 | | |
| 145 | 4737.35 | 3.07 | +0.20 | +0.12 | +0.39 | |
| 145 | 4756.11 | 3.09 | +0.30 | +0.08 | +0.46 | |
| 150 | 4500.30 | 3.07 | | -0.03 | | |
| 150 | 4511.90 | 3.07 | 0.00 | +0.04 | +0.14 | |
| 155 | 4209.76 | 3.09 | | +0.25 | | |
| 168 | 4792.51 | 3.10 | | +0.02 | | |
| 168 | 4801.03 | 3.11 | +0.20 | -0.02 | +0.34 | |
| 186 | 4689.37 | 3.11 | | -0.09 | | |
| 186 | 4698.46 | 3.13 | | +0.18 | | |
| 186 | 4708.04 | 3.15 | +0.30 | -0.05 | +0.46 | |
| 186 | 4718.43 | 3.18 | +0.40 | +0.02 | +0.47 | |
| 186 | 4664.80 | 3.11 | | +0.03 | | |
| 196 | 4526.11 | 3.36 | | +0.04 | | |

TABLA 1 (continuación)

| Mult. | $\lambda(\text{Å})$ | $\chi(\text{eV})$ | log gf | $\log \frac{W_c}{\lambda v}$ | log η | Remarks |
|-------|---------------------|-------------------|--------|------------------------------|------------|---------|
| 233 | 4622.49 | 3.54 | | -0.08 | | |
| 247 | 4297.74 | 3.83 | | -0.06 | | |
| Cr II | | | | | | |
| 18 | 4217.07 | 3.09 | | +0.17 | | e,A |
| 18 | 4113.24 | 3.09 | | +0.20 | | |
| 19 | 4087.63 | 3.09 | | +0.18 | | |
| 19 | 4088.90 | 3.09 | | +0.22 | | |
| 26 | 4086.14 | 3.70 | | +0.35 | | |
| 26 | 4132.41 | 3.74 | | +0.64 | | |
| 26 | 4229.81 | 3.81 | | +0.22 | | |
| 30 | 4812.35 | 3.85 | -1.50 | +0.38 | +1.87 | |
| 30 | 4824.13 | 3.85 | | +0.30 | | |
| 30 | 4836.22 | 3.84 | | +0.13 | | |
| 30 | 4848.24 | 3.85 | | +0.18 | | |
| 31 | 4275.57 | 3.84 | | +0.46 | | |
| 31 | 4284.21 | 3.84 | | +0.48 | | |
| 44 | 4555.02 | 4.05 | | +0.53 | | |
| 44 | 4558.66 | 4.06 | -0.60 | +0.73 | +2.53 | |
| 44 | 4588.22 | 4.05 | -0.80 | +0.65 | +2.37 | |
| 44 | 4592.09 | 4.06 | -1.10 | +0.54 | +2.07 | |
| 44 | 4618.83 | 4.06 | | +0.38 | | |
| 44 | 4634.11 | 4.05 | -0.90 | +0.57 | +2.28 | |
| 162 | 4145.77 | 5.30 | | +0.35 | | |
| 165 | 4081.21 | 5.30 | | +0.31 | | |
| Mn I | | | | | | |
| 2 | 4034.49 | 0.00 | | +0.61 | | e,A |
| 5 | 4041.36 | 2.11 | | +0.57 | | |
| 5 | 4070.28 | 2.11 | | +0.24 | | |
| 21 | 4709.72 | 2.88 | -0.10 | -0.03 | +0.22 | |
| 21 | 4739.11 | 2.93 | -0.20 | -0.10 | +0.09 | |
| 21 | 4761.53 | 2.94 | 0.00 | -0.02 | +0.28 | |
| 21 | 4762.38 | 2.88 | +0.50 | +0.20 | +0.85 | |
| 21 | 4765.86 | 2.93 | +0.10 | +0.09 | +0.39 | |
| 22 | 4451.59 | 2.88 | | +0.29 | | |
| 22 | 4470.14 | 2.93 | -0.20 | -0.11 | -0.58 | |
| 23 | 4265.92 | 2.93 | | +0.04 | | |
| Fe I | | | | | | |
| 1 | 4375.93 | 0.00 | -3.00 | +0.59 | +2.33 | f,A |
| 1 | 4389.24 | 0.05 | | -0.15 | | |
| 2 | 4427.31 | 0.05 | -2.48 | +0.63 | +2.72 | f |
| 2 | 4461.65 | 0.09 | -3.03 | +0.48 | +2.24 | f |
| 3 | 4199.97 | 0.09 | | +0.16 | | |
| 3 | 4216.19 | 0.00 | | +0.55 | | |
| 3 | 4291.47 | 0.05 | | +0.17 | | |
| 18 | 4139.93 | 0.99 | | +0.08 | | |
| 19 | 4174.92 | 0.91 | | +0.43 | | |
| 39 | 4531.15 | 1.48 | | +0.44 | | |
| 39 | 4547.02 | 1.55 | | +0.28 | | |
| 39 | 4592.66 | 1.55 | -2.29 | +0.41 | +1.78 | i |
| 39 | 4602.00 | 1.60 | -3.11 | +0.07 | +0.87 | j |

TABLA 1 (continuación)

| Mult. | $\lambda(\text{\AA}^\circ)$ | $\chi(\text{eV})$ | $\log gf$ | $\log \frac{W_c}{\lambda \nu}$ | $\log \eta$ | Remarks |
|-------|-----------------------------|-------------------|-----------|--------------------------------|-------------|---------|
| 39 | 4602.94 | 1.48 | -2.16 | +0.48 | +1.97 | f |
| 39 | 4632.92 | 1.60 | | +0.29 | | |
| 40 | 4765.48 | 1.60 | | 0.00 | | |
| 41 | 4383.55 | 1.48 | | +0.79 | | |
| 41 | 4404.75 | 1.55 | -0.13 | +0.74 | +3.88 | g,h |
| 41 | 4415.12 | 1.60 | -0.54 | +0.76 | +3.44 | f,g,h |
| 42 | 4147.67 | 1.48 | | +0.49 | | |
| 42 | 4202.03 | 1.48 | -0.57 | +0.82 | +3.48 | f |
| 42 | 4250.79 | 1.55 | | +0.67 | | |
| 42 | 4271.76 | 1.48 | | +0.74 | | |
| 43 | 4071.74 | 1.60 | | +0.81 | | |
| 43 | 4143.87 | 1.55 | | +0.69 | | |
| 68 | 4408.42 | 2.19 | | +0.39 | | |
| 68 | 4430.62 | 2.21 | -1.51 | +0.54 | +2.00 | f |
| 68 | 4442.34 | 2.19 | | +0.56 | | |
| 68 | 4447.72 | 2.21 | | +0.55 | | |
| 68 | 4459.12 | 2.17 | -1.21 | +0.53 | +2.33 | f |
| 68 | 4494.57 | 2.19 | -1.05 | +0.57 | +2.47 | f,g,h |
| 68 | 4528.62 | 2.17 | -0.74 | +0.79 | +2.76 | f |
| 69 | 4447.13 | 2.19 | | 0.00 | | |
| 71 | 4282.41 | 2.17 | -0.71 | +0.63 | +2.52 | f,g,h |
| 71 | 4352.74 | 2.21 | -1.27 | +0.51 | +2.23 | d |
| 115 | 4630.13 | 2.27 | -2.45 | -0.04 | +0.98 | g |
| 152 | 4187.80 | 2.41 | | +0.76 | | |
| 152 | 4210.35 | 2.47 | -0.89 | +0.59 | +2.38 | f |
| 152 | 4222.22 | 2.44 | -0.92 | +0.57 | +2.38 | f |
| 152 | 4235.94 | 2.41 | -0.25 | +0.75 | +2.41 | f |
| 152 | 4250.12 | 2.46 | | +0.63 | | |
| 152 | 4260.48 | 2.39 | +0.04 | +0.73 | +2.39 | f |
| 152 | 4271.16 | 2.44 | | +0.62 | | |
| 217 | 4067.28 | 2.55 | | +0.58 | | |
| 217 | 4078.36 | 2.60 | | +0.54 | | |
| 217 | 4095.98 | 2.58 | | +0.46 | | |
| 273 | 4242.59 | 2.72 | | +0.31 | | |
| 346 | 4683.56 | 2.82 | | -0.10 | | |
| 346 | 4741.53 | 2.82 | | -0.06 | | |
| 347 | 4687.39 | 2.82 | | -0.13 | | |
| 349 | 4635.85 | 2.83 | | -0.17 | | |
| 350 | 4422.57 | 2.83 | -1.05 | +0.40 | +1.96 | f |
| 350 | 4443.20 | 2.85 | | +0.36 | | |
| 350 | 4454.38 | 2.82 | -1.15 | +0.22 | +1.83 | f |
| 350 | 4466.55 | 2.82 | -0.62 | +0.62 | +2.38 | f |
| 350 | 4476.02 | 2.83 | | +0.62 | | |
| 351 | 4241.11 | 2.82 | | -0.02 | | |
| 352 | 4207.13 | 2.82 | -1.14 | +0.43 | +1.85 | f |
| 352 | 4226.43 | 2.83 | | +0.49 | | |
| 352 | 4245.26 | 2.85 | | +0.51 | | |
| 354 | 4107.49 | 2.82 | -0.80 | +0.41 | +2.18 | f |
| 354 | 4175.64 | 2.83 | | +0.55 | | |
| 355 | 4154.50 | 2.82 | | +0.58 | | |

TABLA I (continuación)

| Mult. | $\lambda(\text{\AA})$ | $\chi(\text{eV})$ | $\log gf$ | $\log \frac{W_c}{\lambda \nu}$ | $\log \eta$ | Remarks |
|-------|-----------------------|-------------------|-----------|--------------------------------|-------------|---------|
| 355 | 4184.90 | 2.82 | -0.82 | +0.52 | +2.16 | f |
| 355 | 4203.99 | 2.83 | | +0.60 | | |
| 355 | 4213.65 | 2.83 | -1.10 | +0.40 | +1.18 | f |
| 356 | 4122.52 | 2.83 | | +0.70 | | |
| 357 | 4091.56 | 2.82 | | -0.03 | | |
| 357 | 4109.81 | 2.83 | | +0.44 | | |
| 357 | 4114.45 | 2.82 | -0.45 | +0.33 | +1.92 | f |
| 358 | 4085.01 | 2.83 | | +0.48 | | |
| 359 | 4079.85 | 2.85 | | +0.34 | | |
| 409 | 4661.98 | 2.98 | | -0.18 | | |
| 409 | 4710.29 | 3.00 | | +0.40 | | |
| 409 | 4740.34 | 3.00 | | +0.16 | | |
| 413 | 4326.76 | 2.94 | | +0.15 | | |
| 414 | 4304.55 | 2.94 | | +0.14 | | |
| 414 | 4309.38 | 2.94 | | +0.53 | | |
| 415 | 4365.90 | 2.98 | | -0.10 | | |
| 419 | 4196.53 | 2.94 | | +0.46 | | |
| 418 | 4196.53 | 2.94 | | +0.46 | | |
| 419 | 4160.56 | 2.94 | | +0.41 | | |
| 422 | 4089.23 | 2.94 | | +0.20 | | |
| 424 | 4066.60 | 2.98 | | +0.37 | | |
| 467 | 4712.10 | 3.00 | | -0.10 | | |
| 469 | 4490.08 | 3.00 | | +0.14 | | |
| 476 | 4387.90 | 3.06 | | +0.30 | | |
| 476a | 4182.38 | 3.00 | | +0.42 | | |
| 476a | 4260.14 | 3.06 | | +0.51 | | |
| 478 | 4273.87 | 3.06 | | 0.00 | | |
| 482 | 4220.35 | 3.06 | | +0.42 | | |
| 482 | 4248.23 | 3.06 | | +0.38 | | |
| 482 | 4267.83 | 3.10 | | +0.34 | | |
| 516 | 4436.93 | 3.03 | | +0.16 | | |
| 517 | 4343.70 | 3.03 | | -0.02 | | |
| 518 | 4369.77 | 3.03 | -0.89 | +0.34 | +1.95 | f |
| 520 | 4298.04 | 3.03 | | +0.50 | | |
| 521 | 4225.96 | 3.03 | | +0.41 | | |
| 522 | 4199.10 | 3.03 | +0.18 | +0.65 | +2.99 | h |
| 523 | 4143.42 | 3.03 | | +0.61 | | |
| 524 | 4074.79 | 3.03 | | +0.49 | | |
| 554 | 4568.79 | 3.25 | | -0.04 | | |
| 554 | 4574.24 | 3.20 | -2.57 | -0.04 | +0.09 | g |
| 554 | 4598.12 | 3.27 | | +0.12 | | |
| 554 | 4625.05 | 3.23 | -0.18 | +0.44 | | |
| 555 | 4504.84 | 3.25 | | -0.11 | | |
| 557 | 4069.08 | 3.28 | | -0.03 | | |
| 557 | 4080.89 | 3.28 | | +0.06 | | |
| 558 | 4073.76 | 3.25 | | +0.47 | | |
| 558 | 4097.10 | 3.27 | | 0.21 | | |
| 558 | 4098.18 | 3.23 | -0.74 | +0.22 | +1.87 | f |
| 558 | 4109.07 | 3.28 | | +0.12 | | |
| 559 | 4067.98 | 3.20 | | +0.54 | | |

TABLA 1 (continuación)

| Mult. | $\lambda(\text{\AA}^\circ)$ | $\chi(\text{eV})$ | $\log gf$ | $\log \frac{W_c}{\lambda \nu}$ | $\log \eta$ | Remarks |
|-------|-----------------------------|-------------------|-----------|--------------------------------|-------------|---------|
| 559 | 4085.31 | 3.23 | | +0.60 | | |
| 588 | 4788.76 | 3.22 | -1.66 | -0.06 | +1.00 | g |
| 588 | 4839.55 | 3.25 | | +0.10 | | |
| 593 | 4518.45 | 3.22 | | +0.03 | | |
| 594 | 4537.68 | 3.25 | | -0.09 | | |
| 597 | 4285.44 | 3.22 | | +0.36 | | |
| 597 | 4327.92 | 3.29 | | +0.09 | | |
| 635 | 4776.07 | 3.29 | | -0.10 | | |
| 638 | 4594.96 | 3.26 | | 0.00 | | |
| 688 | 4741.08 | 3.32 | | -0.15 | | |
| 689 | 4168.62 | 3.35 | | +0.12 | | |
| 689 | 4200.93 | 3.38 | | +0.41 | | |
| 689 | 4224.18 | 3.35 | | +0.57 | | |
| 691 | 4306.58 | 3.42 | | +0.31 | | |
| 693 | 4227.43 | 3.32 | +0.36 | +0.71 | +2.90 | f |
| 693 | 4238.82 | 3.38 | | +0.52 | | |
| 693 | 4247.43 | 3.35 | -0.21 | +0.60 | +2.34 | f |
| 694 | 4154.81 | 3.35 | | +0.62 | | |
| 694 | 4168.94 | 3.40 | | +0.11 | | |
| 695 | 4090.98 | 3.35 | | +0.08 | | |
| 695 | 4114.96 | 3.35 | | +0.28 | | |
| 695 | 4150.26 | 3.42 | | +0.50 | | |
| 695 | 4157.79 | 3.40 | | +0.56 | | |
| 695 | 4158.80 | 3.42 | | +0.52 | | |
| 695 | 4176.57 | 3.35 | | +0.58 | | |
| 697 | 4106.44 | 3.38 | | +0.27 | | |
| 698 | 4065.40 | 3.42 | | +0.04 | | |
| 698 | 4072.52 | 3.42 | | +0.37 | | |
| 698 | 4084.50 | 3.32 | | +0.49 | | |
| 700 | 4090.08 | 3.38 | | +0.26 | | |
| 723 | 4566.99 | 3.40 | | +0.04 | | |
| 726 | 4137.00 | 3.40 | | +0.52 | | |
| 752 | 4705.46 | 3.53 | | -0.23 | | |
| 753 | 4789.65 | 3.53 | -0.92 | +0.24 | +1.50 | g |
| 755 | 4547.85 | 3.53 | | +0.17 | | |
| 761 | 4327.10 | 3.53 | | +0.20 | | |
| 795 | 4587.13 | 3.56 | | +0.10 | | |
| 799 | 4201.73 | 3.56 | | +0.36 | | |
| 800 | 4219.36 | 3.56 | +0.05 | +0.62 | +2.43 | f |
| 819 | 4572.86 | 3.64 | | -0.16 | | |
| 820 | 4643.47 | 3.64 | -0.89 | +0.27 | +1.43 | i |
| 820 | 4673.17 | 3.64 | -0.82 | +0.32 | +1.53 | i |
| 820 | 4690.15 | 3.67 | | +0.01 | | |
| 820 | 4701.05 | 3.67 | | -0.04 | | |
| 821 | 4678.85 | 3.59 | -0.60 | +0.27 | +1.76 | f |
| 822 | 4638.02 | 3.59 | | +0.36 | | |
| 822 | 4728.56 | 3.64 | | +0.15 | | |
| 823 | 4560.10 | 3.59 | | +0.08 | | |
| 825 | 4495.99 | 3.64 | | -0.07 | | |
| 826 | 4611.28 | 3.64 | -0.70 | +0.52 | +1.63 | i |

TABLA I (continuación)

| Mult. | $\lambda(\text{\AA}^{\circ})$ | $\chi(\text{eV})$ | log gf | $\log \frac{W}{\lambda} \frac{c}{v}$ | log η | Remarks |
|-------|-------------------------------|-------------------|--------|--------------------------------------|------------|---------|
| 827 | 4495.57 | 3.59 | | +0.05 | | |
| 828 | 4438.35 | 3.67 | | +0.06 | | |
| 828 | 4446.84 | 3.67 | | +0.13 | | |
| 828 | 4484.23 | 3.59 | -0.66 | +0.41 | +1.71 | f |
| 829 | 4523.40 | 3.64 | | -0.11 | | |
| 830 | 4388.41 | 3.59 | | +0.44 | | |
| 830 | 4423.86 | 3.64 | | +0.09 | | |
| 830 | 4433.22 | 3.64 | | +0.44 | | |
| 830 | 4469.38 | 3.64 | -0.35 | +0.32 | +1.98 | f |
| 830 | 4476.08 | 3.67 | | +0.62 | | |
| 830 | 4485.68 | 3.67 | | +0.26 | | |
| 849 | 4309.04 | 3.62 | | +0.22 | | |
| 903 | 4360.81 | 3.63 | | +0.04 | | |
| 906 | 4088.57 | 3.62 | | +0.26 | | |
| 906 | 4236.76 | 3.62 | | -0.01 | | |
| 906 | 4243.37 | 3.62 | | +0.14 | | |
| 906 | 4246.09 | 3.63 | | +0.44 | | |
| 971 | 4593.54 | 3.93 | | -0.08 | | |
| 973 | 4392.58 | 3.86 | | -0.20 | | |
| 976 | 4276.68 | 3.86 | | +0.08 | | |
| 993 | 4264.74 | 3.94 | | -0.18 | | |
| 994 | 4243.79 | 3.87 | | +0.03 | | |
| 1073 | 4085.98 | 4.14 | | +0.23 | | |
| 1103 | 4112.97 | 4.16 | | +0.33 | | |
| 1103 | 4125.62 | 4.20 | | +0.45 | | |
| 1133 | 4734.10 | 4.28 | | -0.06 | | |
| 1206 | 4749.93 | 4.54 | -1.48 | +0.02 | +0.09 | j |
| Fe II | | | | | | |
| 27 | 4416.82 | 2.77 | -2.34 | +0.63 | +2.51 | i,A |
| 37 | 4515.34 | 2.83 | -2.41 | +0.71 | +2.35 | i,k,l |
| 37 | 4520.22 | 2.83 | -2.55 | +0.69 | +2.25 | i,k,l |
| 38 | 4508.28 | 2.84 | -2.30 | +0.69 | +2.66 | i,k,l |
| 38 | 4522.63 | 2.83 | -2.10 | +0.83 | +2.67 | i,k |
| 38 | 4541.52 | 2.84 | -2.57 | +0.64 | +2.23 | i |
| 38 | 4576.33 | 2.83 | -2.90 | +0.58 | +1.91 | l |
| 38 | 4583.83 | 2.79 | -1.82 | +0.77 | +2.99 | i,l,k |
| 38 | 4620.51 | 2.82 | -3.27 | +0.47 | +1.57 | l |
| Co I | | | | | | |
| 16 | 4020.90 | 0.43 | -1.59 | +0.17 | +0.60 | a,B |
| 27 | 4699.18 | 1.04 | | +0.11 | | |
| 28 | 4121.32 | 0.92 | -0.03 | +0.44 | +1.68 | |
| 29 | 4110.53 | 1.04 | -0.80 | +0.30 | +0.81 | |
| 58 | 4068.54 | 1.95 | -0.49 | -0.08 | +0.32 | |
| 58 | 4086.30 | 1.87 | -0.27 | +0.29 | +0.64 | |
| 150 | 4478.32 | 3.09 | -0.33 | -0.30 | +0.43 | |
| 150 | 4517.09 | 3.11 | +0.27 | -0.18 | +0.15 | |
| Ni I | | | | | | |
| 52 | 4331.64 | 1.67 | | +0.15 | | m,A |
| 86 | 4462.46 | 3.45 | -0.41 | +0.24 | +0.74 | |
| 86 | 4470.48 | 3.38 | -0.13 | +0.25 | +1.08 | |

TABLA I (continuación)

| Mult. | $\lambda(\text{Å}^\circ)$ | $\chi(\text{eV})$ | $\log gf$ | $\log \frac{W_c}{\lambda \nu}$ | $\log \eta$ | Remarks |
|-------|---------------------------|-------------------|-----------|--------------------------------|-------------|---------|
| 98 | 4648.66 | 3.40 | -0.01 | +0.59 | +1.22 | |
| 98 | 4686.22 | 3.58 | -0.49 | +0.31 | +0.60 | |
| 98 | 4715.78 | 3.53 | -0.19 | +0.46 | +0.94 | |
| 98 | 4756.52 | 3.47 | -0.21 | +0.22 | +0.95 | |
| 113 | 4703.81 | 3.64 | | +0.36 | | |
| 146 | 4763.95 | 3.64 | | +0.14 | | |
| 168 | 4437.57 | 3.66 | | +0.10 | | |
| 197 | 4072.91 | 3.83 | | -0.02 | | |
| Ni II | | | | | | |
| 9 | 4244.80 | 4.01 | | +0.23 | | |
| 9 | 4362.10 | 4.01 | | +0.34 | | |
| 10 | 4192.07 | 4.01 | | +0.27 | | |
| Zn I | | | | | | |
| 2 | 4722.16 | 4.01 | | +0.49 | | |
| 2 | 4810.53 | 4.06 | | +0.49 | | |
| Sr II | | | | | | |
| 1 | 4077.71 | 0.00 | +0.18 | +1.04 | +4.02 | n,B |
| 1 | 4215.52 | 0.00 | -0.11 | +0.89 | +3.76 | |
| 3 | 4305.45 | 3.03 | | +0.53 | | |
| Y II | | | | | | |
| 5 | 4358.73 | 0.10 | -0.71 | +0.36 | +1.50 | n̄,B |
| 5 | 4398.02 | 0.13 | -0.35 | +0.45 | +1.83 | |
| 13 | 4374.94 | 0.41 | +0.76 | +0.69 | +2.70 | |
| 14 | 4177.54 | 0.41 | +0.66 | +0.88 | +2.54 | |
| Zr II | | | | | | |
| 40 | 4317.32 | 0.71 | -1.60 | -0.30 | -0.49 | e,A |
| 42 | 4150.97 | 0.80 | -1.02 | +0.27 | +0.10 | a |
| 43 | 4050.32 | 0.71 | -1.30 | -0.60 | -0.23 | e |
| Ba II | | | | | | |
| 1 | 4554.03 | 0.00 | +0.17 | +0.78 | +3.20 | a,B |
| 4 | 4166.00 | 2.71 | -0.39 | +0.22 | +0.42 | |
| La II | | | | | | |
| 8 | 4662.51 | 0.00 | -2.04 | +0.02 | +0.44 | a,B |
| 24 | 4333.76 | 0.17 | -0.60 | +0.46 | +1.76 | |
| 25 | 4322.51 | 0.17 | -1.62 | -0.04 | +0.70 | |
| 52 | 4605.78 | 0.71 | -1.68 | +0.13 | +0.22 | |
| 53 | 4364.66 | 0.65 | -1.76 | +0.01 | +0.15 | |
| 75 | 4286.97 | 1.94 | +0.28 | +0.38 | +1.17 | |
| 75 | 4692.50 | 1.75 | -0.52 | -0.07 | +0.52 | |
| 76 | 4269.50 | 1.77 | +0.03 | +0.01 | +1.02 | |
| 77 | 4378.10 | 1.77 | -0.65 | -0.13 | +0.32 | |
| 81 | 4719.93 | 1.95 | -0.55 | -0.07 | +0.30 | |
| Ce II | | | | | | |
| 1 | 4186.60 | 0.38 | +0.67 | +0.39 | +1.18 | a,C |
| 1 | 4248.68 | 0.20 | -0.06 | +0.20 | +0.58 | |
| 1 | 4562.36 | 0.00 | -0.07 | +0.28 | +0.76 | |
| 1 | 4628.16 | 0.04 | -0.14 | +0.29 | +0.67 | |
| 2 | 4137.65 | 0.04 | +0.09 | +0.46 | +0.87 | |
| 2 | 4382.17 | 0.20 | -0.17 | +0.11 | +0.48 | |
| 2 | 4418.78 | 0.38 | +0.03 | +0.12 | +0.55 | |

TABLA I (continuación)

| Mult. | $\lambda(\text{Å})$ | $\chi(\text{eV})$ | $\log gf$ | $\log \frac{W_c}{\lambda \nu}$ | $\log \eta$ | Remarks |
|-------|---------------------|-------------------|-----------|--------------------------------|-------------|---------|
| 2 | 4460.21 | 0.00 | +0.02 | +0.21 | +0.84 | |
| 2 | 4523.08 | 0.04 | -0.45 | +0.07 | +0.32 | |
| 2 | 4560.96 | 0.20 | -0.70 | -0.08 | -0.06 | |
| 3 | 4483.90 | 0.38 | -0.14 | 0.00 | +0.35 | |
| 4 | 4073.48 | 0.00 | +0.05 | +0.22 | +0.84 | |
| 6 | 4593.93 | 0.22 | -0.26 | +0.13 | +0.39 | |
| 11 | 4118.14 | 0.22 | -0.13 | +0.05 | +0.46 | |
| 36 | 4222.60 | 0.12 | -0.44 | +0.35 | +0.29 | |
| 57 | 4486.91 | 0.29 | -0.62 | -0.05 | -0.06 | |
| 60 | 4083.23 | 0.70 | -0.04 | +0.20 | +0.17 | |
| 81 | 4255.78 | 0.70 | -0.27 | +0.14 | -0.04 | |
| 82 | 4068.84 | 0.70 | -0.36 | +0.03 | -0.17 | |
| 112 | 4120.83 | 0.32 | -0.74 | -0.05 | -0.23 | |
| 202 | 4449.34 | 0.61 | -0.34 | +0.15 | -0.02 | |
| Nd II | | | | | | |
| 10 | 4156.08 | 0.18 | -0.49 | +0.49 | +1.56 | a,C |
| 19 | 4075.27 | 0.06 | -1.38 | +0.24 | +0.74 | |
| 19 | 4133.36 | 0.32 | -1.15 | +0.09 | +0.74 | |
| 50 | 4144.56 | 0.20 | -1.72 | +0.23 | +0.29 | |
| 50 | 4462.98 | 0.56 | -0.84 | +0.16 | +0.90 | |
| Sm II | | | | | | |
| 3 | 4676.91 | 0.04 | -1.39 | -0.30 | +0.19 | a,C |
| 36 | 4434.32 | 0.38 | -0.75 | +0.16 | +0.59 | |
| 36 | 4642.24 | 0.38 | -1.12 | -0.18 | +0.19 | |
| 45 | 4424.34 | 0.48 | -0.42 | +0.31 | +0.84 | |
| Eu II | | | | | | |
| 1 | 4129.73 | 0.00 | -0.31 | +0.54 | +2.03 | a,C |
| 1 | 4205.05 | 0.00 | -0.08 | +0.63 | +2.26 | |
| Gd II | | | | | | |
| 15 | 4212.00 | 0.42 | -0.46 | +0.29 | +0.78 | a,C |
| 17 | 4162.73 | 0.49 | -0.75 | +0.08 | +0.42 | |
| 32 | 4215.02 | 0.43 | -0.58 | +0.07 | +0.63 | |
| 43 | 4316.05 | 0.66 | -0.66 | -0.19 | +0.36 | |
| 62 | 4483.33 | 1.06 | -0.70 | -0.16 | +0.00 | |

REMARKS:

Sources of f-values:

- a Corliss and Bozman, 1962
b Kurucz, 1973
c Wolnik and Berthel, 1973
d Roberts, Andersen and Sorensen, 1973
e Holweger, 1967
f Wolnik, Berthel and Wares, 1970
g Garz and Kock, 1969
h Bridges and Wiese, 1970
h Bredges and Wiese, 1970
i Wolnik, Berthel and Wares, 1971
j Richter and Wulff, 1970

k Roder, 1962

l Baschek et al., 1970 (raised by +0.2)

m Garz et al., 1970

n Penkin, 1964

ñ From a relation Corliss and Bozman vs. Holweger

o Lambert and Wagner, 1968

Sources of partition functions:

A Bolton, 1970

B Cayrel and Jugaku, 1963

C Aller and Everett, 1972

Table 1 gives the line intensities and other pertinent data taken from Moore (1959). In the table are also given $\log W_c$

— — and $\log \eta$. Here v is the most probable velocity of the atoms given by

$$v = \sqrt{\frac{2kT}{M} + \zeta^2}$$

M is the mass of the atom, T the gas kinetic temperature, k the Boltzmann constant and ζ , the turbulent velocity. The sources of f -values and partition functions are listed in the remarks to the table.

Curve of growth analysis

From the different theoretical curves published, Wrubel's curves for the scattering mechanism and the Milne-Eddington, model were selected. The family of curves for B0 2 and for $\log a = -2.6$ was chosen. Here

$$a = \frac{\Gamma}{4\pi\Delta v_0} ; \Delta v_0 = \frac{v_0}{c} \cdot v$$

Γ is the effective damping constant; both collision with neutral hydrogen atoms and classical radiation damping were considered. It has been assumed that the continuous absorption is due to the neutral hydrogen to the negative hydrogen and to Rayleigh scattering; tables of these, for a large range of temperature and electron pressure, were calculated with the IBM/360 computer of the La Plata University. The formulae used were those given by Mihalas (1967).

Atmospherical parameters

Baschek and Oke (1965) determined effective temperature and gravities for certain Am, Ap and normal A-type stars through the use of the spectrum scanning technique. They obtained for τ U Ma.

$$\theta_{\text{eff}} = 0.67 \quad \log g = 4.0$$

Another means of obtaining the stellar effective temperature uses effective temperature-color index relations. Matsushima (1969) gives a relation between uvby pho-

tometric system and effective temperature from stellar atmospheres computations. As $b-y = 0.217$ (Stromgren and Perry, 1965) one obtains

$$\theta_{\text{eff}} = 0.686$$

Geneve's photometric systems gives another through $(B_2 - V_1)$ index (Hauck, 1968). Using the relation

mean for determine effective temperatures

$$\theta_{\text{eff}} = 0.727 (B_2 - V_1) + 0.649$$

one obtains

$$\theta_{\text{eff}} = 0.736$$

Finally, one wants mention here that Praderie (1967) in her analysis of Am stars gives for τ U Ma $\theta_{\text{eff}} = 0.68 \pm 0.02$, accord to the results of Oke and Conti (1966) and the H γ profile.

The following parameters were finally adopted:

$$\theta_{\text{eff}} = 0.69 \quad \log g = 4.0$$

With these values and for an optical depth $\tau_{\text{st}} = 0.1$ the values of the other atmospheric parameters were obtained interpolating in Mihalas models (1964).

This value of the optical depth was chosen because of van't Veer-Menneret's work (1963) on 63 Tau where he showed that $\tau = 0.1$ is the most representative depth from the consignation and excitations level of the atmosphere.

In particular, $\log Pe$ was found to be 0.973. This value was also determined using the equivalent widths of the hydrogen lines (published by Greenstein 1948) as suggested by Unsold (1941). It resulted $\log Pe = 2.81$ which is very different from the previous one. This is due to the fact that the hydrogen lines are formed in deeper layers than $\tau = 0.1$ which is representative mostly for the lines of metals. On the other hand it must be remembered that not all but only a few hydrogen line could be used for the above mentioned calculation.

The microturbulent velocity

The microturbulent velocity was determined using a plot of $\log \frac{W}{\lambda}$ vs. $\log gf\lambda$ for lines of several elements. As Fe is the ele-

ment with major number of lines, it influences greatly in the determination.

First, Corlis and Bozman's gf values were used and two different values resulted for neutral and ionized atoms:

$$\begin{aligned}\zeta_t &= 4.1 \text{ km/seg} && \text{for neutral atoms} \\ \zeta_t &= 4.5 \text{ km/seg} && \text{for ionized atoms}\end{aligned}$$

This rather bizarre result was found in several other Am stars.

In a second attempt, new values of gf were used, with the interesting result that an unique value for both neutral and ionized atoms results:

$$\zeta_t = 3.30 \text{ km/seg}$$

This microturbulent velocity is relatively low compared to the values obtained for other Am stars, but it is in good agreement

with the result obtained by Smith (1973) in a recent investigation about the microturbulence in A stars.

Table 2 gives the values of the parameters obtained presently, and those of Greenstein. When comparing, it should be kept in mind that Greenstein used a different representative depth in the atmosphere, namely $\tau_{st} = 0.25$. It is evident that the values used by Greenstein for temperature and effective gravity were too low.

Abundances

Having thus obtained the fundamental parameters, one can proceed with the determination of abundances, following the well known technique of the curve of growth. The curves for several elements are given in figures 1, 2, 3, 4 and 5.

TABLE 2
Atmospherical parameters of τ UMa

| | Miczaika et al 1956 | Present analysis |
|----------------|------------------------|---------------------|
| τ_{st} | 0.25 | 0.1 |
| V_{turb} | 3.8 km/seg | 3.30 km/seg |
| θ_{ion} | 0.86 | 0.826 |
| $\log P_e$ | +0.12 | 0.97 |
| $\log P_g$ | +2.9 | 4.20 |
| $\log g$ | 2.2 | 4.0 |

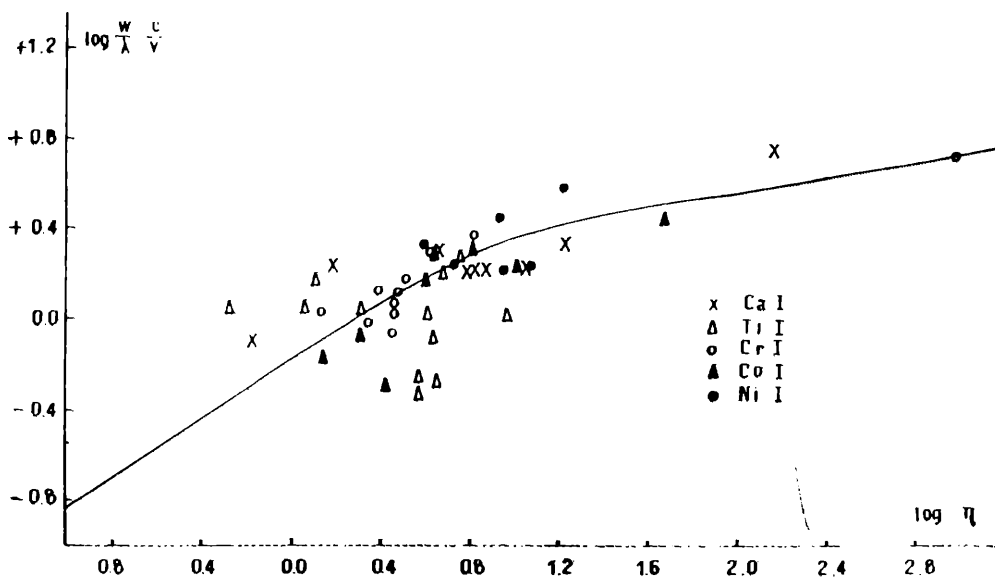


Fig. 1 — Curve of growth for Ca I, Ti I, Cr I, Co I and Ni I.

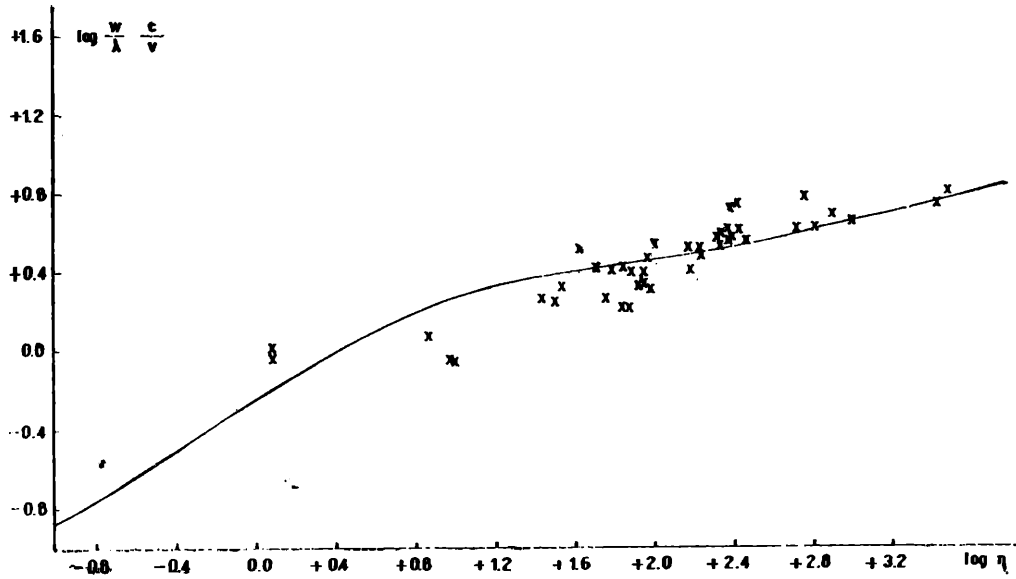


Fig. 2 — Curve of growth for Fe I.

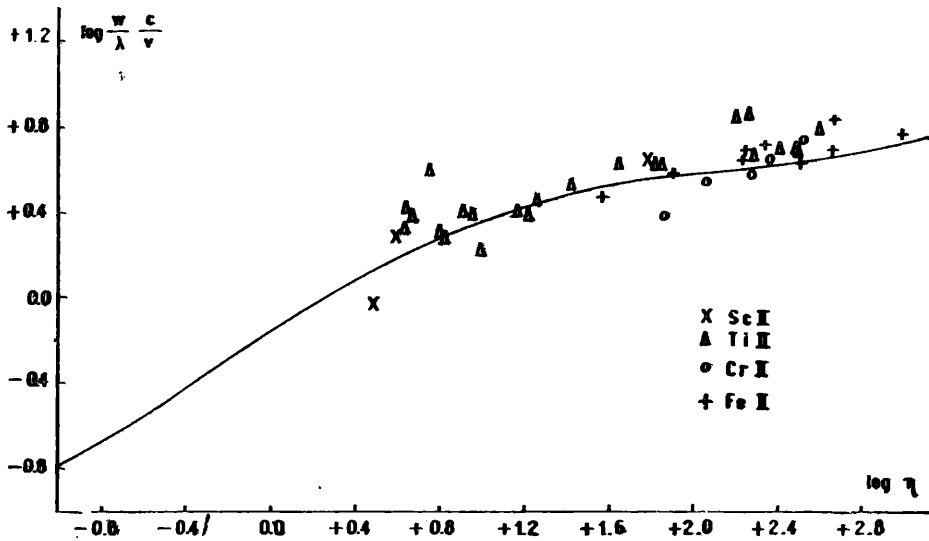


Fig. 3 — Curve of growth for Sc II, Ti II, Cr II and Fe II.

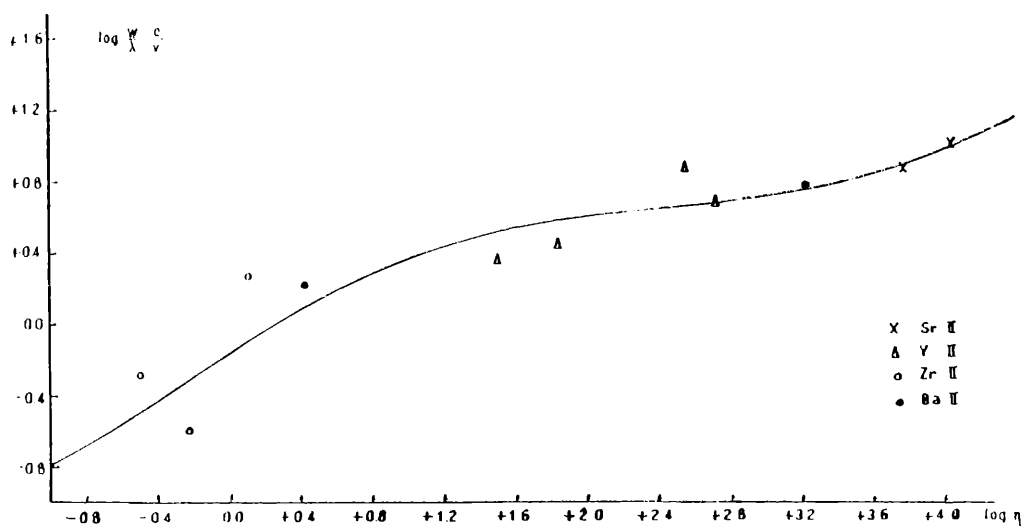


Fig. 4 — Curve of growth for Sr II, Y II, Zr II and Ba II.

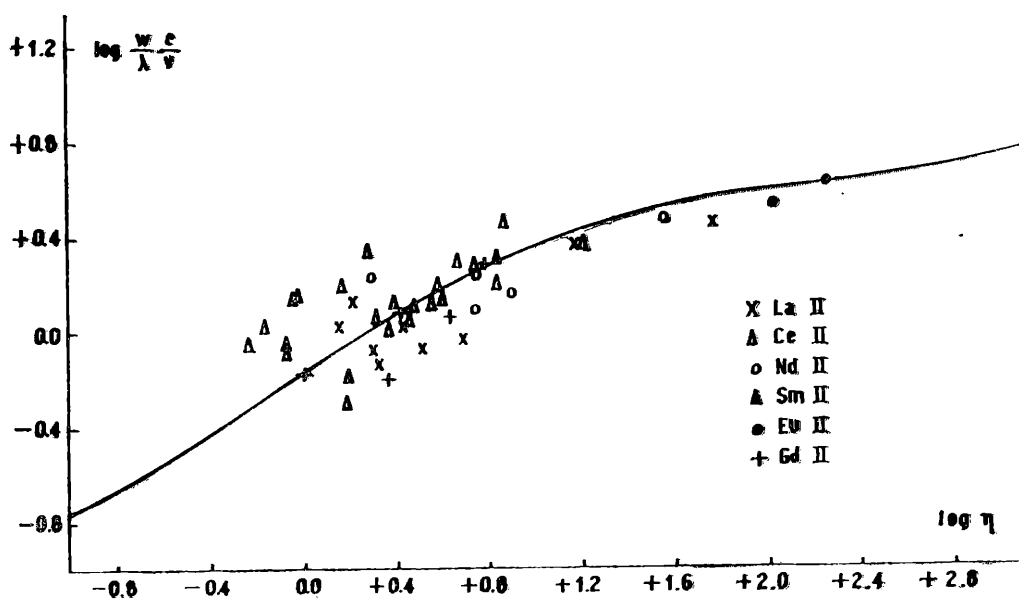


Fig. 5 — Curve of growth for the rare-carths.

Table 3 summarizes the abundances of τ UMa compared with the normal scale of abundances derived by Aller (1968). For Iron the most recent determination of $\epsilon = 7.28$ (Foy, 1972).

The quality of the abundance determination, according to the number of lines, the source of the oscillator strength and the scatter for one element, is indicated by number (5: the highest quality). The abundances will be discussed in detail below.

The main results are that both Ca and Sc are deficient, which is characteristic of the Am stars; the iron peak elements, ex-

cept V and Mn, whose abundances are not well determined, are overabundant. Of the heavier elements, Sr and Y are the most enhanced ones.

There is no evidence of the existence of elements with atomic number between 41 and 55 (Mo, Pd, Ag, Cd, Xe) which are present in some of the coolest Ap stars (see Jaschek and Jaschek, 1971). Ba ($Z = 56$) is also present. The rare earth group is represented by La, Ce, Pr, Nd, Sm, Eu, and Gd). Definitely absent are Tb, Dy, Ho, Cr, Tm, and Lu.

TABLE 3

Abundances

For each element is specified: element, absolute abundances of τ UMa $\log \epsilon_*$, the relative abundances compared to the sun $[\log \epsilon] = \log \epsilon_* - \log \epsilon_{\odot}$, the quality of the abundance determination, the results of previous analysis (Miczaika et al, 1956, van't Veer - Menneret, 1966).

| Element | $\log \epsilon_*$ | $[\log \epsilon]$ | Quality | $[\log \epsilon]$ Miczaika et al | $[\log \epsilon]$ van't Veer-Menneret |
|---------|-------------------|-------------------|---------|-------------------------------------|--|
| Na | P | | | +0.9 | |
| Mg | P | | | +0.2 | |
| Al | P | | | +0.5 | |
| Si | P | | | +0.2 | |
| Ca | 5.4 | -1.0 | 1 | -0.6 | -0.3 |
| Sc | 2.7 | -0.3 | 1 | -1.1 | -0.7 |
| Ti | 5.0 | +0.4 | 5 | -0.2 | +0.4 |
| V | 3.6 | -0.5 | 1 | -0.4 | +0.4 |
| Cr | 6.3 | +1.1 | 5 | +0.3 | +0.8 |
| Mn | 4.8 | -0.1 | 1 | +0.3 | +0.6 |
| Fe | 7.8 | +0.6 | 5 | +0.2 | +0.7 |
| Co | 4.8 | +0.2 | 2 | | |
| Ni | 6.1 | +0.4 | 2 | +1.0 | |
| Zn | P | | | +0.7 | |
| Sr | 3.3 | +0.4 | 3 | 0 | +0.9 |
| Y | 2.5 | +0.9 | 2 | +0.1 | +1.0 |
| Zr | 2.5 | -0.2 | 1 | -1.0 | +0.6 |
| Ba | 2.7 | +1.00 | 1 | +0.1 | |
| La | 3.0 | +1.0 | 2 | | |
| Ce | 2.4 | +0.4 | 3 | | |
| Nd | 3.4 | +1.5 | 1 | | |
| Sm | 2.5 | +0.9 | 1 | 0.00 | +1.3 |
| Eu | 2.6 | +1.6 | 1 | | |
| Gd | 2.6 | +1.5 | 1 | | |

P: elements which are present but only with a few number of blended lines.

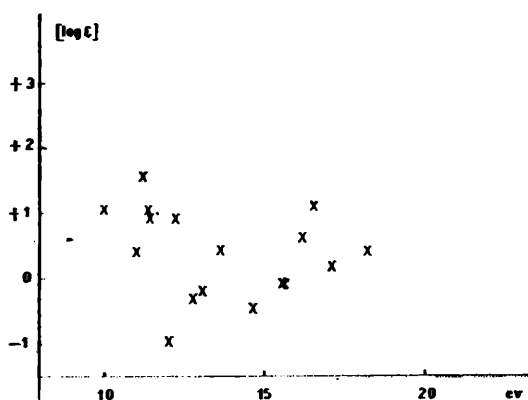


Fig. 6—The dependence of the relative abundances $[\log \epsilon]$ in τ U Ma from the 2nd ionization potential.

In view of recent results indicating the presence of very heavy elements ($Z < 71$) a careful search was made for them. No evidence was found for any element heavier than the rare earth group. This could constitute a major difference with cool Ap stars if it could be confirmed in other Am stars. With the different atmospheric parameters used by the authors (mainly temperature and electron pressure) one must expect different abundances. A glance at table 3 shows this to be true. A comparison with Miczaika et al. values shows that their abundances are in general lower by a factor five. The differences with van't Veer-Menneret are not large.

Since this author considered his abundances as provisional we will not analyze them further.

In the following detailed analysis the element are collected groupwise.

Sodium, Magnesium, Aluminium and Silicon

These elements are present with only a few number of blended lines. So, one can not obtain a good estimation of their abundances.

Calcium and Scandium

Scandium is represented with only three lines belonging to a same multiplet; a weak underabundance results but the determination is not very accurate. The estimation of Ca abundance is also in accurate;

we have only a group of eight lines well identified.

The Iron group

Except for Vanadium, Manganese and Cobalt, the abundances are derived from many well classified lines. The error can not be larger than $\Delta \log \epsilon = \pm 0.03$.

The abundance of Vanadium is derived of only three weak lines, so the error in the determination is very large.

The abundance of Mn is obtained from lines that are in the region λ 4700-4800, when the quality of the plate it bad and the continuum very difficult to fix.

Cobalt is also represented by only very weak lines, which show a considerable scatter.

Strontium, Yttrium and Zirconium

Strontium is represented by the most strong lines; his abundance seems to be low.

Yttrium and Zirconium are present with four and three lines respectively. The overabundance of Y seems to be real but the abundance of Zr seems to be affected of a large error.

Barium, Lanthanum and the rare-earths

The abundances of these elements are not of very great accuracy because they are represented by only a few number of lines; but the overabundance seems to be real.

Finally, the dependence of the abundances on three different factors is studied: a) the second ionization potential; b) the atomic number and c) the solar abundance.

One can see that there is no correlation in cases a) and b), but that a relation exists in case c): the lower the normal element abundance is, the higher is the overabundances in τ U Ma. The peculiar elements Ca, Sc and also Zr (not well determined) which are underabundant, and Cr, Fe and Ni which seem to be overabundant, show a deviation respect to the general behaviour.

Discussion

The spectral anomalies of τ U Ma can be due to of the following factors:

- an anormal structure of the atmosphere
- an anormal chemical composition.

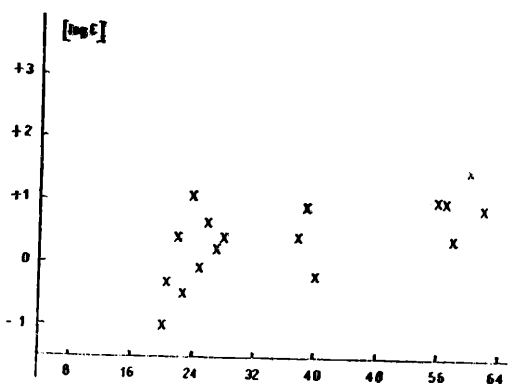


Fig. 7 — The dependence of the relative abundances $[\log \epsilon]$ in τ U Ma from the atomic number z .

One can see from the analysis that the atmospheric parameters are the proper of a normal main sequence star with the same effective temperature.

Then, it is supposed that the anomalous line intensities are due entirely to real abundance differences. Several mechanisms has been proposed to explain these anomalies observed in Am stars.

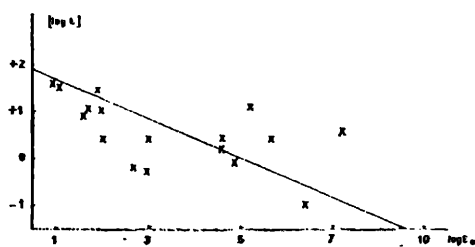


Fig. 8 — The dependence of the relative abundances in τ U Ma from normal (solar abundances $\log \epsilon_0$).

Following the work of Michaud (1970) on the diffusive separation of elements in Ap stars, several investigators (Watson, 1971 a, b; Smith, 1971; Stickland-Whelan, 1972) have applied the theory of element separation to the Am stars.

This process can explain satisfactorily the result showed in fig. 7, specially the overabundance of the heavier elements. In agreement with this theory they are pushed outward because they are less abundant a priori.

The deficiency of Ca and Sc can also be explained by this process; it is related to the fact that their ionic states are near the configuration of Ne and Ar respectively.

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