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Preliminary report

SCALE HEIGHTS FOR THE AERONOMICAL MODELS AND PERTURBATIONS OF SATELLITE ORBITS

S. Šegan and N. Pejović

Institute of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Yugoslavia

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SUMMARY: The general expressions for the scale heights in aeronomic atmospheric density models are given.

1. INTRODUCTION

All "aeronomic" models are usable for the determination of the orbital perturbations merely over one revolution of a satellite around the Earth. The determination of the orbital changes under the influence of the atmospheric drag just over one revolution is a common procedure adopted in the present theories.

The computation of the density scale heights has been applied not only for determining the density at perigee, but also for the determining any orbital element $\{.\} \in (a, e, i, \Omega, \omega)$ and we have (Lagrangian equations in Gaussian form, (King-Hele, 1964)):

$$\frac{d\Theta}{dE} = -f_1(a)\delta f_2(e, E)\rho\binom{sin}{cos}^k i\binom{sin}{cos}^l u, \qquad (1)$$

where
Θ – (a, e, i, Ω, ω)
a – semi-major axis,
e – eccentricity,
... – ....
E – eccentric anomaly,
δ – drag force per unit mass (satellite dependent),
ρ – atmospheric density,
z – altitude,
H – density scale height.

Parameter ρ is unknown. It will be also used for the determination of the effective height, which is actually the perigee height plus $H/2$.

Since the latest trend in the modeling of the upper atmosphere properties (Hedin, 1987) is characterized by the use of spherical harmonic representation of a specific atmospheric parameter

$$\rho = \rho(z, F, F_b, \varphi, ...),$$

and

$$H = -\frac{\rho}{d\rho/dz}$$

where
ρ – atmospheric density
F – solar flux
F_b – mean solar flux
φ – latitude
...

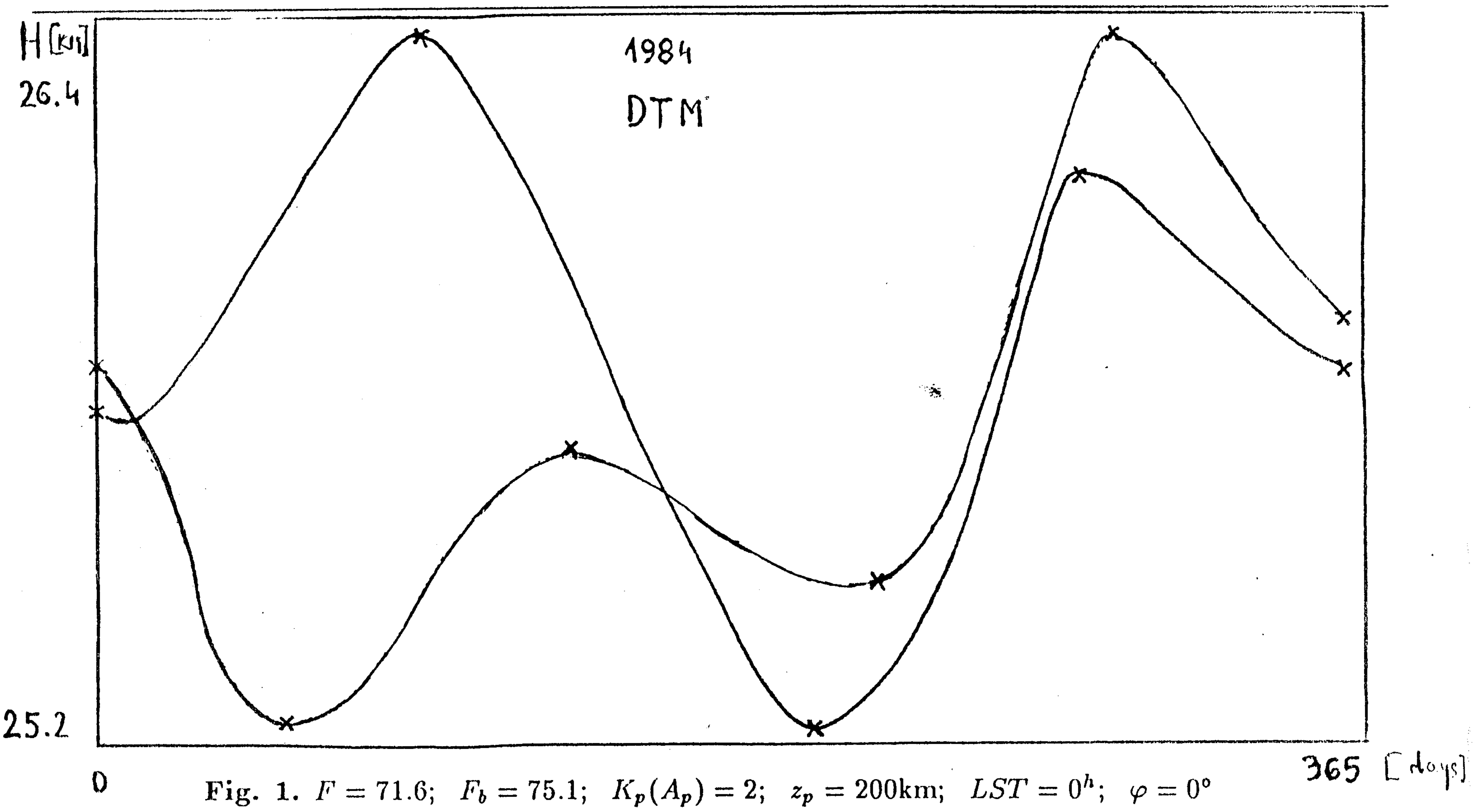

Fig. 1. $F = 71.6$; $F_b = 75.1$; $K_p(A_p) = 2$; $z_p = 200$km; $LST = 0^h$; $\varphi = 0°$

Some of such models were taken into account here. Since the models used not give H explicitly, we shall compute it.

2. COMPUTATION

We have so far assumed that the density scale height H given by

$$H = -\frac{\rho}{d\rho/dz}$$

can be computed from the models itself.

In the aeronomic models the density ρ is given as

$$\rho = \sum_i m_i n_i.$$

For the CIRA72 (Oliver, 1980) it is

$$\rho = \sum_i m_i n_i(z_0) f_i(z'), \qquad (2)$$

where

$$z' = (z - z_0)(R + z_0)/(R + z),$$
$$R = 6356.766 \text{ km},$$
$$z_0 = 125 \text{ km},$$
$$g = 9.80665/(1 + z/R)^2,$$

and

$$n_i(z) =$$
$$= n_i(z_0)((1-a)/(1-a^{-sz'}))^{1+\alpha+1/H_i} exp(z'/H_i),$$

where

$$a = (T_\infty - T_{z_0})/T_\infty,$$
$$s = a_1 + a_2/(T_\infty + a_3),$$
$$H_i = kT_\infty/(m_i g_{z_0}).$$

We sum over i constituents with molecular masses m_i and numerical densities n_i.

The only height dependent function is $f_i(z)$ which results from the integration of the diffussive equilbrium distribution with the temperature profile. Let

$$C_1 = 1 + \alpha + 1/(sH_i),$$

then

$$f_i(z') = ((1-a)/(1-a^{-sz'}))^{C_1} e^{-z'/H_i}.$$

By differentiation of the last expression we derive the equation

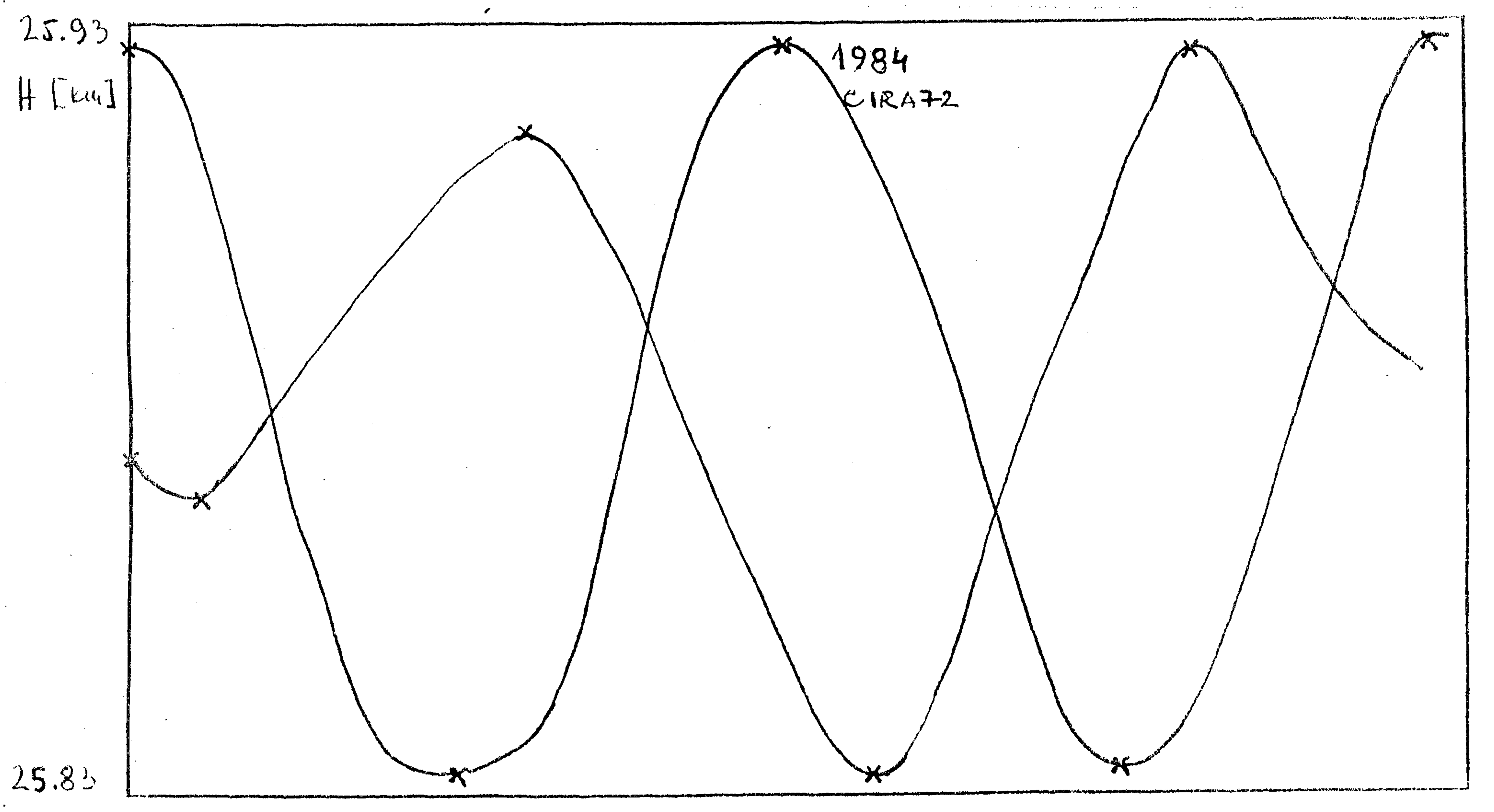

Fig. 2. For the same parameters as on Fig. 1.

$$\frac{d\rho}{dz} =$$

$$= \frac{\sum_i m_i n_i(z_0) f_i(z') \frac{1}{H_i}[-1 - (1+\alpha_i) s H_i a e^{-sz'}]}{(1 - ae^{-sz'})(R+z)^2(R+z_0)^{-2}}. \quad (3)$$

For different models (MSIS, 1978; DTM, 1977; C, 1977; C1986, 1986; ...) and their constituents i

$$M_i = F(MSIS_i, DTM_i, C_i, ...)$$

$$M_i \simeq CIRA_i exp[G_i(L) - 1], \quad (4)$$

where $G_i(L)$ is a function defining global variation of the densities (Šegan, 1987).

The results can be checked on the observed satellite orbital data concerning atmospheric density. We have the observed values for some satellites. We see (Fig.1 & Fig.2) that they have a very interesting look. The changes are nonlinear functions of the height and do not provide reliable information on the evolution of the density whereas the new models fit to the observed values much better. In many cases we must take into account the influences of the orbital elements changes in their complexity. It's clear that aeronomic models are very complicated for the effective usage and in the next paper we shall try to develop much better theory.

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СКАЛЕ ВИСИНЕ ЗА АЕРОНОМСКЕ МОДЕЛЕ И ПОРЕМЕЋАЈЕ САТЕЛИТСКИХ ОРБИТА

С. Шеган и Н. Пејовић

Институт за астрономију, Математички факултет, Студентски трг 16, 11000 Београд, Југославија

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Претходно саопштење

У раду је дат општи израз за скалу висина у аерономским моделима густина атмосфера.