Notes on the Butikov tide paper PhL 1.20.17

This is an 11 page paper written 2001. Author Eugene is at St Pete Russia.

[I] Introduction. He will to the static ellipse thing, but then will study the dynamic "waves" which the tides of course imply.

II. THE TIDE-GENERATING FORCES: AN ELEMENTARY APPROACH

He defines my same Frame S' similar to a "frying pan in the hands of a cook". Talks about how to teach this subject to students. On page 2 his four points of interest are these (he does sun, not moon)

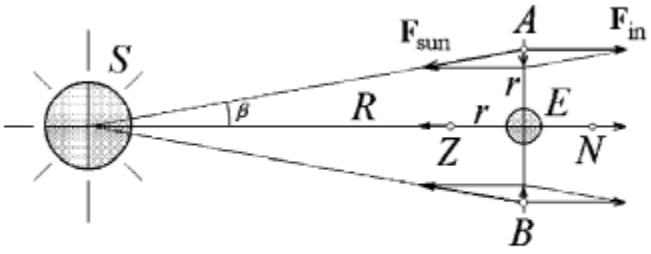

Fig. 1. Sun-induced tide-generating forces at different points A, B, Z, and N.

[3] He gets the four point forces in this section but not the general formula yet.

III. TIDAL FORCES AT AN ARBITRARY POINT NEAR THE EARTH

He quickly gets the formula of interest,

$$\mathbf{F}_{\text{tid}} = \mathbf{F}_{\text{sun}} + \mathbf{F}_{\text{in}} = -GmM_{\text{sun}}\left(\frac{\mathbf{r}_s}{r_s^3} - \frac{\mathbf{R}}{R^3}\right).$$

and an approximate version

$$\mathbf{F}_{\text{tid}} \approx -G\frac{mM_{\text{sun}}}{R^3}\left[(\mathbf{R}+\mathbf{r})\left(1-\frac{3(\mathbf{R}\cdot\mathbf{r})}{R^2}\right)-\mathbf{R}\right]$$
$$\approx -G\frac{mM_{\text{sun}}}{R^3}\left[\mathbf{r}-3\mathbf{R}\frac{(\mathbf{R}\cdot\mathbf{r})}{R^2}\right]. \qquad (4)$$

IV. HORIZONTAL AND VERTICAL COMPONENTS OF THE TIDAL FORCE

[4] Here he does what I do in my polar coordinates expression of the tidal force. And he drops the constant factor I mention,

$$F_{\text{vert}} = (3/2)(r/R)F_{\text{sun}} \cos 2\theta,$$
$$F_{\text{hor}} = -(3/2)(r/R)F_{\text{sun}} \sin 2\theta, \qquad (7)$$

and he has this

$$F_{\text{tidal}}/F_{\text{grav}} = (3/2)(M_{\text{moon}}/M_{\text{earth}})(r_0/R)^3 \approx 8.6\times 10^{-8}. \qquad (8)$$

supporting my claim of 10^{-7} good!

V. THE STATIC DISTORTION OF THE WATER SURFACE

Gets the result

$$2a = (3/2)r_0(M_{\text{sun}}/M_{\text{earth}})(r_0^3/R^3). \qquad (11)$$

and quotes the 54 and 24 cm standard results. Why do I always say 53 and 24? Maybe fix this! ****

[5]

VI. TIDAL FORCES ON THE ROTATING EARTH

But we are not concerned here with this constant distortion of the earth because this distortion is independent of the apparent position of the celestial body that produces the tides. Therefore, the centripetal acceleration of the axial rotation adds nothing to tidal forces. However, the daily rotation of

So as I do, he ignores the centrifugal force on the rotating Earth. Mentions that the tidal field is "quadrupole" in nature. What does that really mean? The field has quadrupole moments I guess. I know how to compute the q moments of a charge distribution, but how does that apply here to the tidal force? I cannot get a quick explanation so I won't use this word.

He claims to be able to describe the tidal force at some θ' byut I don't see any fancy equations, so I don't think he does what I do on this subject.

VII. THE POTENTIAL FUNCTION FOR TIDAL FORCES

[6] Here author uses the potential method to obtain the same tide height number a, similar to Taylor. So Butikov can claim to do both methods.

$$F_{\text{vert}} = Ar\cos 2\theta = -\partial U_{\text{tides}}(r,\theta)/\partial r,$$
$$F_{\text{hor}} = -Ar\sin 2\theta = -(1/r)\partial U_{\text{tides}}(r,\theta)/\partial\theta. \qquad (13)$$

Therefore, the potential function for the tidal forces can be written as:

$$U_{\text{tides}}(r,\theta) = -(1/2)Ar^2\cos 2\theta$$
$$= -(3/4)(GmM_{\text{sun}}/R^3)r^2\cos 2\theta. \qquad (14)$$

VIII. THE NATURAL WAVE AND THE DRIVING TIDAL FORCES

OK, I just scanned the rest of the doc on forced oscillations and read none of it. Done here.