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Comment

Comment on "Observational evidence for travelling wave modes bearing distance proportional shifts" by V. Guruprasad

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In a recent paper, Guruprasad [1] proposed an explanation of spacecraft flyby anomalies based on a theoretical model of traveling waves.

In order to contrast the theory against measurements, experimental data from the measured range disagreement of 1998 NEAR flyby were used [2]. (I believe that "disagreement" is a better term than "error" to describe this anomaly of the NEAR spacecraft.) Although the disagreement was detected during an Earth flyby, it should be distinguished from the so-called flyby anomaly [3] which refers to an unexpected energy increase during Earth flybys of spacecraft.

The ranging data are obtained from the time delay of the radio signals, and are independent of the Doppler data, although the time-integrated Doppler frequency should equal the range variation. The range disagreement detected by Antreasian and Guinn [2] is the difference in the range measured by the Millstone and Altair tracking stations of the Space Surveillance Network (SSN) relative to the expected range according to the trajectory obtained from the Deep Space Network (DSN). The actual flyby anomaly [3] remains unexplained in Guruprasad's paper.

The main objections to the paper by Gurusprasad, besides the former one, are the following: a) loose estimates of orbital data are used, while the orbital parameters are readily available [2]; b) an unrealistic relationship between range error and range is used; and c) no statistical significance of the agreement between model and measurements is given.

An example of the poor estimates is given on page 5, left column, where it is written "The uniformity of the 10 min ticks in the equatorial view ([9], fig. 1 and of similar ticks in the north polar view ([14], fig. 9), which are expanded due to projection, suggest that the mean speed $v_o \equiv 6.85\,\mathrm{km\,s^{-1}}$ would be adequate for present purposes." In other words, the used mean radial speed is obtained from the author's interpretation of a published figure, instead of actual data. In fig. 1 total and radial speeds of NEAR are plotted. The mean radial velocity is about 8 km/s during SSN traking, that is, 17% larger than the used estimate.

The consequence is that the fit of fig. 1 of [1] changes appreciably. The fit relies on a relationship described on page 2, right column, as "Denoting the instantaneous range errors as Δr, and the radial speed as v_o, the lag times in the figure are given by $\Delta t = \Delta r/v_o$, and the one-way ranges, by $r = c\Delta t - r_e \approx c\Delta r/v_o - r_e$, where $r_e \equiv 6.371\,\mathrm{km}$, the Earth's radius." That is, a linear relatioship between range, r, and range disagreement, Δr, is proposed. In fig. 2, the plot of the above relationship using both $v_o = 6.85\,\mathrm{km/s}$ (the asymptotic speed used by Gurusprasad), and $v_o = 8\,\mathrm{km/s}$ (the actual speed) is given. Also, they are compared to the actual relationship for Millstone (Δr from measurements and r from orbital data). Differences are so large (as much as more than half the Earth radius) that clearly invalidate the relationship with the radial speed proposed by Gurusprasad.

Further, although the above relationship can be presented as a *de facto* correlation, from a physical viewpoint there is no justification on why range (r) and Earth radius (r_e) may appear arithmetically added. The Earth

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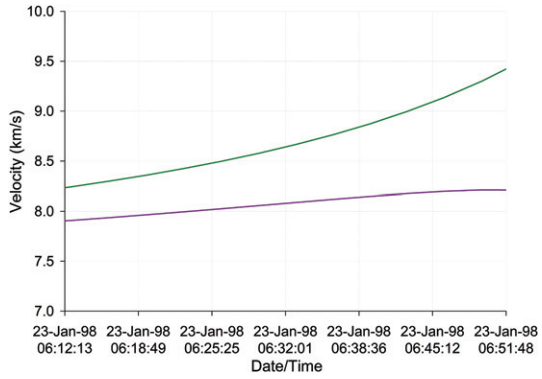

Fig. 1: (Colour online) Speed of NEAR (green, upper line) and radial speed (magenta, lower line) during SSN tracking.

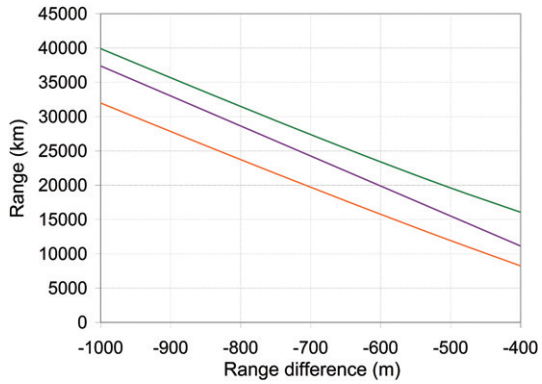

Fig. 2: (Colour online) Range as a function of range difference. Guruprasad's proposed model with $v_o = 6.85\,\mathrm{km/s}$ [1] (magenta, middle line), proposed model with $v_o = 8\,\mathrm{km/s}$ (the actual speed) (orange, lower line), and actual relationship for Millstone (green, upper line).

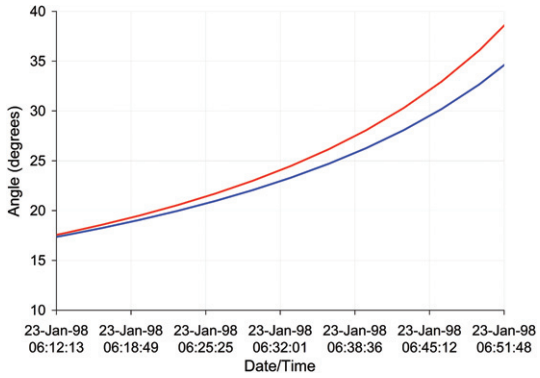

Fig. 3: (Colour online) Angle between trajectory of NEAR and line of sight to SSN antennas: Millstone (blue, lower line) and Altair (red, upper line).

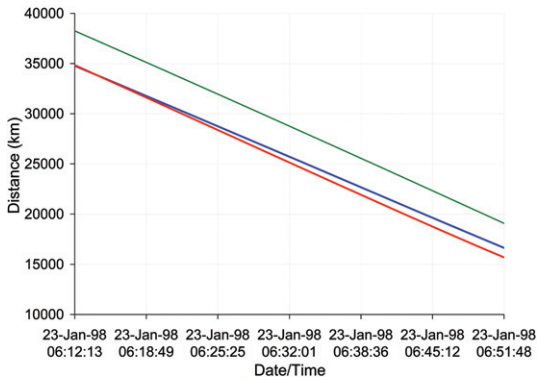

Fig. 4: (Colour online) Orbital radius of NEAR (green, upper line), range from Millstone (blue, middle line) and range from Altair (red, lower line).

radius relates to the position of the detectors, but the direction from the Earth center to the radar is not parallel to the range, which points from the radar to the spacecraft. Thus, one should expect the appearance of an angle cosine in the formula.

Another example of poor (wrong) estimates is on page 5, right column, where it is written "the trajectory pointed towards Millstone initially, implying a faster initial decrease of the range,...". This is not true. In fig. 3 the angle between the trajectory and the line of sight to the SSN antennas are plotted. As can be seen, initially the trajectory points equally to both antennas (about 17.5 degrees). Further, as is shown in fig. 4, initially (and during the whole coverage) Altair has a faster decrease of the range, not Millstone as stated by Guruprasad.

Finally, no statistical significance is referred to in the paper. Only vague percentage figures are mentioned. For example, referring to the one-way delay on page 5, left column, it is said to be "about 25% smaller than in fig. 1." Or, the Doppler amplitude, "These are about 20% of the reported 760 mHz = 13.5 mm s^{-1}." How good are these figures? Do they have any statistical significance?

Orbital parameters are readily accesible, thus the actual orbit of spacecrafts is easily obtained. A test of the theory could be conducted in a more precise way.

As presented by Guruprasad, the theory seems to roughly agree with wrong estimates, thus giving the impression that the theory is not supported by actual data.

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