A SIMPLE RECIPE FOR COMPUTING THE SATELLITE'S ORBITAL VELOCITY CORRECTION

At present, the IUE data reduction routines express the intensities in terms of a wavelength scale defined in the rest frame of the instrument. Therefore, in addition to corrections for the earth's motion around the sun and a transformation to some particular reference frame (e.g. LSR, star's frame, etc.), one must compensate for the projection of the satellite's orbital motion around the earth. The magnitude of this correction can be as large as $\pm$ 3.9 km s^{-1}, which may not be negligible for some studies requiring accurate radial velocity comparisons. For those of us who wish not to spend a day or so becoming acquainted with the fascinating world of orbital dynamics and angular coordinate transformations,* here is a straightforward guide on how to carry out the computations with not much fuss. The hard part, figuring out all those funny angles between the parts of an orbit and your target, has already been done by the IUE people when they made up that SKYMAP plot for you.

STEP 1: Measure the x and y Cartesian coordinates (in centimeters) of the target with respect to the center of the SKYMAP.

STEP 2: Compute the angles

ω = 11.25 deg/cm (x - 24.0 cm) + argument of perigee

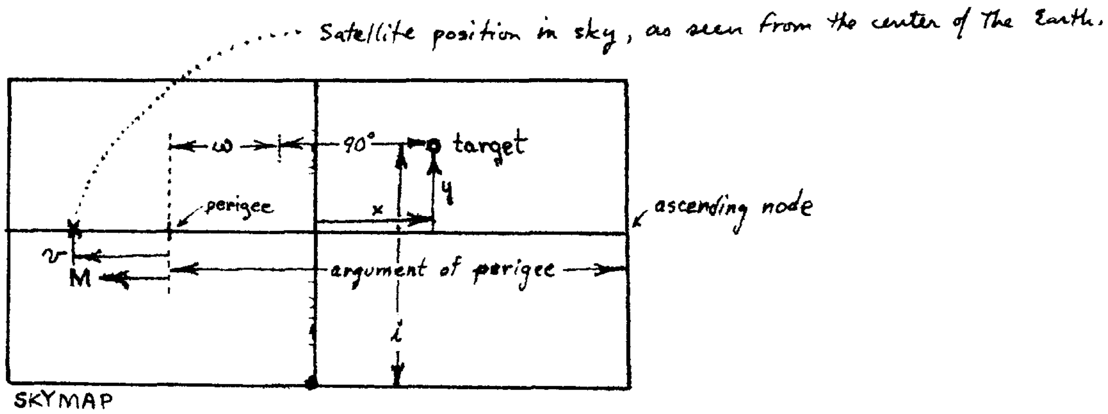
and i = 11.25 deg/cm (y + 8.0 cm)

The argument of perigee is the angular distance along the orbit between the satellite's ascending node, shown at the far right of the SKYMAP, and the point of perigee. The point of perigee, as seen from the earth's center, is on the orbital plane where the band outlined by little E's becomes skinny (not fat; remember that the SKYMAP depicts the earth's appearance from IUE's vantage point). This angle is hard to measure on the SKYMAP, you should obtain this

---

*For those who do, see, e.g., W. M. Smart's book on Spherical Astronomy, 4th ed (Cambridge Univ. Press, 1949) pp 108-120, 357-360.

from the orbital elements which can be provided by YFRA.*



STEP 3: Find out where the satellite was when you took your spectrum. In principle, this can be done by looking at the time tick marks near the top of the SKYMAP and adding 180°. The relevant angle to measure is v, which the experts call the true anomaly, between the satellite position and its perigee. Unfortunately, from the author's experience the SKYMAPS can have errors as large as 18°, because outdated orbital elements have been used. It's probably better to again consult YFRA and obtain the mean anomaly M_o (where the satellite would be if it were going in a perfect circle instead of an ellipse)at an epoch t_o near your observing interval, together with the satellite's period p. Then one can compute the mean anomaly at some time t by evaluating

$$M = 360° \text{ frac } [(t - t_o)/p + M_o/360°]$$

and derive v from the expansion

$$v = M + (2e - e^3/4) \sin M + (5e^2/4) \sin 2M + (13e^3/12) \sin 3M$$

which is accurate to within one or two tenths of a degree for an orbit having an eccentricity e as low as that of IUE (e = 0.239).

---

*Your Friendly Resident Astronomer

STEP 4: The geocentric radial velocity of the satellite in the direction of the target may now be computed using the formula

$$\frac{dz}{dt} = \frac{n\ a\ \sin i}{(1 - e^2)^{1/2}} \ [\cos(v + \omega) + e \cos \omega]$$

where the n is the mean angular motion $2\pi/p$, and a is the orbit's semi-major axis. Numerically, the quantity $na/(1 - e^2)^{1/2}$ is about equal to 3.17 km s^{-1}.

Edward B. Jenkins
Princeton University Observatory
April 16, 1979