position requires complicated calculations or nontrivial observations and measurements, so that the order of magnitude of the error γ must be considerably greater than that of the error β. References [320] and [13] both discuss this systematic error. Some authors estimate the value of γ to be about $20'$ or $30'$. Our calculations give a value of $\gamma \approx 20'$.

6.3. Random errors and spikes. Let us consider the star (from our list T) with Baily number i, with l_i and b_i being its ecliptical coordinates. We denote by $L_i(t, \tau, \beta, \gamma)$ and $B_i(t, \tau, \beta, \gamma)$ the ecliptical longitude and latitude of this star, calculated for time t, and taking into account the proper motion of the star and the errors τ, β, and γ. From a modern catalogue (i.e., for $t = 0$), we determine the equatorial coordinates α_i, δ_i of the i-th star and calculate the coordinates $\alpha_i(t), \delta_i(t)$ of the same star at time t. These coordinates are converted to ecliptical ones (for the same time t) using the equation of ecliptic oscillation, the precession angle, and the corresponding rotation of the angle $\varepsilon(t)$ about the equinoctial axis. Then we rotate the ecliptic for the same small angles β, γ, and τ. In other words, we determine (for time t) the ecliptic perturbations defined by the systematic errors β, γ, and τ. The resulting star coordinates are then $L_i(t, \tau, \beta, \gamma)$ and $B_i(t, \tau, \beta, \gamma)$, using the same ecliptic coordinate system as was used by the compiler of the Almagest star catalogue. It is now possible to compare the Almagest coordinates l_i, b_i of the i-th star with its calculated coordinates $L_i(t, \tau, \beta, \gamma)$, $B_i(t, \tau, \beta, \gamma)$.

Let us consider the following latitudinal and longitudinal deviations:

$$\Delta_b(i, t, \beta, \gamma) = B_i(t, \beta, \gamma) - b_i,$$
$$\Delta_l(i, t, \tau, \beta, \gamma) = L_i(t, \tau, \beta, \gamma) - l_i.$$

Here we use the obvious fact that the latitude $B_i(t, \tau, \beta, \gamma)$ (and hence the latitudinal deviation) does not depend upon τ, i.e., $B_i(t, \tau, \beta, \gamma) \equiv B_i(t, \beta, \gamma)$. This is one of the reasons why latitudes are more stable than longitudes. We will mainly use latitudes (which are not affected by the error τ) and consider longitudes only as auxiliary data.

If the measurements for the i-th star do not contain some unforeseen errors (copyist's mistake, refraction, etc.), then the deviations Δ_b and Δ_l must be within the accuracy interval characteristic of the given catalogue. The accuracy of a catalogue may be unknown. Moreover, the author of a catalogue may have chosen as the size of a unit in the catalogue scale the "record" accuracy, that is, the accuracy of observations of the most famous (named) stars. To find and eliminate "spikes", we may use the following method (where the values of β and γ are considered to be given).

1. The deviation $\delta = [\sum_i \Delta_b^2(i, t, \beta, \gamma)/N]^{1/2}$, where N is the number of stars in the list T. In fact, the value of δ does not depend upon t, since most of the stars have small proper motion. Thus we may take the resulting value of δ (or even $\delta/2$) as the "record" accuracy Δ of a given catalogue. The "real" accuracy of the catalogue is the value $2\delta \div 3\delta$. We should also note that about 40% of the stars in the catalogue are within the "record" interval of accuracy.

2. Stars whose coordinates are not within the "record" accuracy of the catalogue must be excluded from the investigation. Either these are "spikes," or else there were large errors in the measurement of their coordinates.