The idea of the proposed method is to determine γ_i and φ_i by mathematical statistics and to compensate for these errors in order to deal with the real observation error only. Such an approach leads us to a dating method. The realization of the method is based on the fact that the parameters γ_i and φ_i have a "group-like nature", i.e., they are the same for certain groups of stars (e.g., for constellations). This is really true in many cases, because γ_i and φ_i do not depend on individual measurements but on preliminary determination of the ecliptic position for the groups mentioned.

We assume that each constellation G in the ancient catalogue has an individual group error (i.e., this error is common for all stars of the constellation) in the determination of the position of the ecliptic pole. Let us parameterize it by the values γ_G and φ_G. That is, for each star $i \in G$, we assume that the equalities $\gamma_i = \gamma_G$ and $\varphi_i = \varphi_G$ are true. Our aim is to estimate γ_G and φ_G for each group G of the catalogue. Note that the Almagest star catalogue contains 48 constellations.

7.3. Analysis of errors. Seven homogeneous regions in the Almagest star atlas. Let us suppose that t is the year of observation. Determine the value

$$\Delta b_i(t,\gamma,\varphi) = b_i - B_i(t) - \gamma_G \sin\left(L_i(t) + \varphi_G\right) \qquad (3)$$

for the i-th star and consider a constellation G containing N stars. Then we calculate values for $\hat{\gamma}_G$ and $\hat{\varphi}_G$ from the condition of minimization of the function

$$\delta_G^2(t,\gamma,\varphi) = \left[\sum_{i=1}^{N_G} \Delta b_i^2(t,\gamma,\varphi)\right] \Big/ N_G \to \min\,, \qquad (4)$$

varying γ and φ. This problem can be easily solved analytically.

Let us call the value

$$\delta_G^{\min}(t) = \delta_G\left(t,\hat{\gamma}_G,\hat{\varphi}_G\right)$$

a minimal mean-square error in the constellation G. We additionally calculate the percentage $p_G^{\min}(t)$ of stars from G which satisfy to the inequality $|\Delta b_i(t,\hat{\gamma}_G,\hat{\varphi}_G)| < 10'$, i.e.,

$$p_G^{\min}(t) = \#\left\{i\colon \left|\Delta b_i\left(t,\hat{\gamma}_G,\hat{\varphi}_G\right)\right| < 10'\right\}/N_G. \qquad (5)$$

The concrete values $\delta_G^{\min}$ and $p_G^{\min}$ for different constellations G are listed below. The calculated values $\hat{\gamma}_G$ and $\hat{\varphi}_G$ are estimates of the real parameters γ_G and φ_G determining the group error. Though it is possible to prove some asymptotic properties of these estimates (see Theorem 1 below), we cannot consider $\hat{\gamma}_G$ and $\hat{\varphi}_G$ too close to the real values γ_G and φ_G because we do not have firm statistical reasons for such closeness, as the total number of stars in the constellations does not exceed 20–30. Consequently, the values $\hat{\gamma}_G$ and $\hat{\varphi}_G$ cannot only serve to calculate a lower bound $\delta_G^{\min}$ for the mean-square latitude error in the constellation G. The value $p_G^{\min}$ gives us some additional useful information about the group errors. We need a considerably larger group of stars to reliably estimate the group error. It turns out that there are seven regions in the Almagest star atlas which differ from one