Computing Tail Length from Two Points of Right Ascension and Declination

One degree of declination is the same regardless of where it is measured in the sky, but this is not the case for right ascension. One hour of right ascension equals an angle of 15°, but this is not necessarily equal to 15° of declination because, as one approaches the celestial pole, the right ascension circles get progressively smaller. Declination, however, is measured always along a great circle. At the north celestial pole, 1° of declination equals 1°, but 360° of right ascension equals zero. As a result, if any part of a tail is more than 20° from the celestial equator, and one desires to determine its length from its right ascension and declination, he/she must use (A.1)

\[ \ell = \text{inv cos}\left[\sin(\delta_1)\sin(\delta_2) + \cos(\delta_1)\cos(\delta_2)\cos(a_1 - a_2)\right] \]  

(A.1)

In this equation, \( \ell \) is the tail length in degrees; \( a_1 \) and \( \delta_1 \) are the respective right ascension and declination of the central condensation (one end of the tail); and \( a_2 \) and \( \delta_2 \) are the respective right ascension and declination of the other end of the tail. If the entire tail lies close to the celestial equator, there would be no need to use (A.1).

By way of example, let’s say that the right ascension (RA) and declinations (Dec.) are: central condensation (RA = 02 h 05 min 21 s or 2.089 h or 31.3°, Dec. = 44.0°N); tip of tail (RA = 0 h 43 min 12 s or 0.72 h or 10.8°, Dec. = 40.0°N). In both cases, the RA is converted to degrees where each hour of RA equals 15°, each minute = 0.25° and each second = 15/3,600 = 0.004167°. In this example, the declination is already in degrees. Since the comet is north of 20°N, one uses (A.1) to determine \( \ell \).

\[ \ell = \text{inv cos}\left[\sin(44.0^\circ)\sin(40.0^\circ) + \cos(44.0^\circ)\cos(40.0^\circ)\cos(31.3^\circ - 10.8^\circ)\right] \]
\[ \ell = \text{inv cos}[0.6947(0.6428) + (0.7193)(0.7660)\cos(20.5^\circ)] \]
\[ \ell = \text{inv cos}[0.4465 + (0.7193)(0.7660)(0.9367)] \]
\[ \ell = \text{inv cos}[0.4465 + 0.5161] \]
\[ \ell = \text{inv cos}[0.9626] = 15.7^\circ \]
If I had determined the length of the tail from the Pythagorean Theorem and assumed that 1° of right ascension equaled 1° of declination, I would have wound up with a length of 20.9°. However, the true length, 15.7°, is the one that must be reported.
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