The idea of the shape-estimation technique is based on experiments that show that brittle fracturing produces multiple fragments of size lesser than or equal to the least dimension of the body [3]. A meteoroid has limited size and mass. The power law has to be constrained at the top of the sample via exponential cutoff:

\[ I(m) = (k_b - 1) / m_b \ln(m_m \gamma) \exp(-m \ln(m_m)) \]

where \( m_m > 0 \) is an arbitrary lower mass limit and \( m_b > m \) is an upper cutoff mass.

**Shape estimation**

The concept of the shape-estimation technique is based on experiments that show that brittle fracturing produces multiple fragments of size lesser than or equal to the least dimension of the body [3].

A meteoroid has limited size and mass. The power law has to be constrained at the top of the sample via an exponential cutoff:

\[ I(m) = (k_b - 1) / m_b \ln(m_m \gamma) \exp(-m \ln(m_m)) \]

where \( m_m > 0 \) is an arbitrary lower mass limit and \( m_b > m \) is an upper cutoff mass.

**Normal CDF**

\[ F(x, \mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{x} e^{-\frac{(t-\mu)^2}{2\sigma^2}} dt \]

\[ \mu = \frac{1}{N} \sum_{i=1}^{N} \ln(m_i), \quad \sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (\ln(m_i) - \mu)^2} \]

**Weibull CDF**

\[ F_W(m, \gamma, \mu) = 1 - \exp\left(-\left(\frac{m}{\mu}\right)\right)^\gamma \]

\[ \mu = M_0 \]

**Grady CDF**

\[ F_GK(x, \mu) = 1 - N(\beta m) \exp\left(-\frac{m}{\mu}\right) \]

\[ N = N_0 \exp\left(-\frac{m}{\mu}\right) \]

**Multimodal distributions**

\[ F_W(m, \omega, \gamma_1, \mu_1, \gamma_2, \mu_2) = \omega \left( 1 - \exp\left(-\frac{m}{\mu_1}\right)^\gamma_1 \right) + (1 - \omega) \left( 1 - \exp\left(-\frac{m}{\mu_2}\right)^\gamma_2 \right) \]

\[ N_W(m, x, \omega) = N \left( 1 - F_W(m, \omega) \right) \]

**Fig. 1:** Complementary cumulative number of fragments \( N(m) \) vs \( \ln(m) \).

1. Observed data,
2. Normal distribution for \( \ln(m) \) with the mean \( \mu=2.52 \) and the standard deviation \( \sigma=1.41 \),
3. Logistic distribution for \( \ln(m) \) with the same mean and deviation.

**Fig. 2:** Complementary cumulative number of fragments \( N(m) \) vs \( m \) (decimal logarithm scale) for the sample.

1. Observed data,
2. Bimodal Weibull distribution with the weighting factor \( \omega=0.8 \), \( \gamma_1=1.1 \) and \( \mu_1=21.1 \), \( \mu_2=140 \).

**Fig. 3:** Complementary cumulative number of fragments \( N(m) \) vs fragment mass \( m \).

1. Observed data,
2. Weibull distribution with the shape parameter \( \mu=11 \) and the scale parameter \( \gamma=1 \).

**Probabilities for missing fragments for Košice meteorite**

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Probability ( p_{\mu_1} ) of singular fragment to occur within the gap (318, 2167.4)</th>
<th>Expected frequency</th>
<th>Probability of complete absence of any fragment from the set within the gap</th>
<th>Probability of 5 or fewer (at least 1) fragments to occur within the gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lognormal</td>
<td>0.011</td>
<td>2.34</td>
<td>0.005</td>
<td>0.224</td>
</tr>
<tr>
<td>Lognormal</td>
<td>0.025</td>
<td>5.42</td>
<td>0.004</td>
<td>0.537</td>
</tr>
<tr>
<td>Bimodal</td>
<td>0.016</td>
<td>1.41</td>
<td>0.032</td>
<td>0.839</td>
</tr>
<tr>
<td>Bimodal</td>
<td>0.029</td>
<td>6.81</td>
<td>0.001</td>
<td>0.324</td>
</tr>
</tbody>
</table>