When is the sum of two sets of lengths a set of lengths?

Let $H$ be a (commutative) atomic monoid, that is a commutative cancellative semi-group where each element can be written as a product of irreducible elements. For a non-invertible element $b \in H$ we say that $n$ is a length of $b$ if there exist irreducibles $a_1, \ldots, a_n$ such that $b = a_1 \ldots a_n$. We denote by $L(b)$ the set of all $n$ such that $n$ is a length of $b$; for an invertible element $b$ we set $L(b) = \{0\}$.

The question to be discussed in this talk is under which conditions (on $H$) the set $L(b) + L(b') = \{n+n': n \in L(b), n' \in L(b')\}$, for $b, b' \in H$, is guaranteed to be again a set of lengths, that is $L(b) + L(b') = L(c)$ for some $c \in H$. Note that $L(b) + L(b') \subset L(bb')$ but the inclusion can be strict.

In particular, we give a complete answer for the case of Krull monoids where each class contains a prime divisors.

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