

**Kawamata, Yujiro**

**Flops connect minimal models.** (English) Zbl 1145.14014  
Publ. Res. Inst. Math. Sci. 44, No. 2, 419-423 (2008).

Let  $(X, B)$  and  $(X', B')$  be two Kawamata log terminal pairs and  $p : X \rightarrow Z$  and  $q : X' \rightarrow Z$  be two birational morphisms that contract no divisors. The rational map  $(q^{-1} \circ p) : X \dashrightarrow X'$  is a flop if  $\rho(X/Z) = \rho(X'/Z) = 1$ ,  $B' = (q^{-1} \circ p)_* B$  and both  $K_X + B$  and  $K_{X'} + B'$  are numerically equivalent to the pull back of a divisor from  $Z$ . The minimal model program predicts that if  $(X, B)$  and  $(X', B')$  are two minimal models, then  $q^{-1} \circ p$  is given by a finite sequence of flops. In the paper under review, the author shows that this is indeed the case. More precisely, he shows that if  $(X, B)$  and  $(X', B')$  are two projective  $\mathbb{Q}$ -factorial terminal pairs where  $K_X + B$  and  $K_{X'} + B'$  are nef and if  $\alpha : X \dashrightarrow X'$  is a birational map such that  $\alpha_* B = B'$ , then  $\alpha$  may be decomposed into a sequence of flops  $\alpha = \alpha_t \circ \dots \circ \alpha_1$ . The proof is based on a result of *C. Birkar, P. Cascini, J. McKernan* and the reviewer [Existence of minimal models for varieties of log general type, Preprint, [arXiv:math/0610203](https://arxiv.org/abs/math/0610203)] and on a result concerning the boundedness of the length of extremal rays.

Reviewer: [Christopher Hacon \(Salt Lake City\)](#)

**MSC:**

[14E30](#) Minimal model program (Mori theory, extremal rays)  
[14E05](#) Rational and birational maps  
[14J32](#) Calabi-Yau manifolds (algebraic-geometric aspects)

Cited in **34** Documents

**Keywords:**

[minimal models](#); [flops](#)

**Full Text:** [DOI](#) [arXiv](#)

**References:**

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- [2] Y. Kawamata, Crepant blowing-up of 3-dimensional canonical singularities and its application to degenerations of surfaces, *Ann. of Math. (2)* 127 (1988), no. 1, 93-163. · [Zbl 0651.14005](#) · [doi:10.2307/1971417](https://doi.org/10.2307/1971417)
- [3] , On the length of an extremal rational curve, *Invent. Math.* 105 (1991), no. 3, 609-611. · [Zbl 0751.14007](#) · [doi:10.1007/BF01232281](https://doi.org/10.1007/BF01232281) · [eudml:143926](https://eudml.org/doc/143926)
- [4] , On the cone of divisors of Calabi-Yau fiber spaces, *Internat. J. Math.* 8 (1997), no. 5, 665-687. · [Zbl 0931.14022](#) · [doi:10.1142/S0129167X97000354](https://doi.org/10.1142/S0129167X97000354) · [arxiv:alg-geom/9701006](https://arxiv.org/abs/alg-geom/9701006)
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