
References

- Abramovich, Dan, and Chen, Qile. 2014. Stable logarithmic maps to Deligne–Faltings pairs II. *Asian J. Math.*, **18**(3), 465–488. cited on page(s): 307
- Abramovich, Dan, and Fantechi, Barbara. 2017. Configurations of points on degenerate varieties and properness of moduli spaces. *Rend. Semin. Mat. Univ. Padova*, **137**, 1–17. cited on page(s): 307
- Abramovich, Dan, and Hassett, Brendan. 2011. Stable varieties with a twist. Pages 1–38 of: *Classification of algebraic varieties*. EMS Ser. Congr. Rep. Eur. Math. Soc., Zurich. cited on page(s): 307
- Abramovich, Dan, and Karu, Kalle. 2000. Weak semistable reduction in characteristic 0. *Invent. Math.*, **139**(2), 241–273. cited on page(s): 173
- Abramovich, Dan, and Vistoli, Angelo. 2000. Complete moduli for fibered surfaces. Pages 1–31 of: *Recent progress in intersection theory (Bologna, 1997)*. Trends Math. Boston, MA: Birkhäuser Boston. cited on page(s): 307
- Abramovich, Dan, and Vistoli, Angelo. 2002. Compactifying the space of stable maps. *J. Amer. Math. Soc.*, **15**(1), 27–75. cited on page(s): 307
- Abramovich, Dan, Cadman, Charles, Fantechi, Barbara, and Wise, Jonathan. 2013. Expanded degenerations and pairs. *Comm. Algebra*, **41**(6), 2346–2386. cited on page(s): 307
- Abramovich, Dan, Chen, Qile, Marcus, Steffen, and Wise, Jonathan. 2017. Boundedness of the space of stable logarithmic maps. *J. Eur. Math. Soc. (JEMS)*, **19**(9), 2783–2809. cited on page(s): 307
- A'Campo, Norbert, Ji, Lizhen, and Papadopoulos, Athanase. 2016 (Feb.). *On the early history of moduli and Teichmüller spaces*. arxiv:1602.07208. cited on page(s): 14, 19
- Adiprasito, Karim, Liu, Gaku, and Temkin, Michael. 2019. *Semistable reduction in characteristic 0*. *Sém. Lothar. Combin.* 82B, Art. 25. cited on page(s): 173
- Alexeev, Valery. 1993. Two two-dimensional terminations. *Duke Math. J.*, **69**(3), 527–545. cited on page(s): 27, 76, 225
- Alexeev, Valery. 1996. Moduli spaces $M_{g,n}(W)$ for surfaces. Pages 1–22 of: *Higher-dimensional complex varieties (Trento, 1994)*. Berlin: de Gruyter. cited on page(s): 306
- Alexeev, Valery. 2002. Complete moduli in the presence of semiabelian group action. *Ann. of Math. (2)*, **155**(3), 611–708. cited on page(s): 27, 307

- Alexeev, Valery. 2006. Higher-dimensional analogues of stable curves. Pages 515–536 of: *International Congress of Mathematicians*, vol. II. Eur. Math. Soc., Zurich. cited on page(s): 218, 221, 315
- Alexeev, Valery. 2008. Limits of stable pairs. *Pure Appl. Math. Q.*, **4**(3, part 2), 767–783. cited on page(s): 307, 418
- Alexeev, Valery. 2015. *Moduli of weighted hyperplane arrangements*. Advanced Courses in Mathematics. CRM Barcelona. Basel: Birkhäuser/Springer. Edited by Gilberto Bini, Martí Lahoz, Emanuele Macrì, and Paolo Stellari. cited on page(s): 218, 221, 307, 315
- Alexeev, Valery. 2016. Divisors of Burniat surfaces. Pages 287–302 of: *Development of moduli theory—Kyoto 2013*. Adv. Stud. Pure Math., vol. 69. Math. Soc. Japan [Tokyo]. cited on page(s): 307
- Alexeev, Valery, and Hacon, Christopher D. 2012. Non-rational centers of log canonical singularities. *J. Algebra*, **369**, 1–15. cited on page(s): 418
- Alexeev, Valery, and Knutson, Allen. 2010. Complete moduli spaces of branchvarieties. *J. Reine Angew. Math.*, **639**, 39–71. cited on page(s): 307, 343
- Alexeev, Valery, and Liu, Wenfei. 2019a. Log surfaces of Picard rank one from four lines in the plane. *Eur. J. Math.*, **5**(3), 622–639. cited on page(s): 26, 307
- Alexeev, Valery, and Liu, Wenfei. 2019b. Open surfaces of small volume. *Algebr. Geom.*, **6**(3), 312–327. cited on page(s): 307
- Alexeev, Valery, and Thompson, Alan. 2021. ADE surfaces and their moduli. *J. Algebraic Geom.*, **30**(2), 331–405. cited on page(s): 307
- Altmann, Klaus, and Kollár, János. 2019. The dualizing sheaf on first-order deformations of toric surface singularities. *J. Reine Angew. Math.*, **753**, 137–158. cited on page(s): 24, 219, 221, 247
- Ambro, Florin. 2003. Quasi-log varieties. *Tr. Mat. Inst. Steklova*, **240**(Biratsion. Geom. Linein. Sist. Konechno Porozhdennye Algebrы), 220–239. cited on page(s): 415, 422
- Ambro, Florin. 2011. Basic properties of log canonical centers. Pages 39–48 of: *Classification of algebraic varieties*. EMS Ser. Congr. Rep. Eur. Math. Soc., Zurich. cited on page(s): 415
- Ambro, Florin, and Kollár, János. 2019. Minimal models of semi-log-canonical pairs. Pages 1–13 of: *Moduli of K-stable varieties*. Springer INdAM Ser., vol. 31. Cham: Springer. cited on page(s): 212
- Arnold V. I., Guseĭn-Zade, S. M., and Varchenko, A. N. 1985. *Singularities of differentiable maps*, vol. I–II. Monographs in Mathematics, vol. 82–83. Boston, MA: Birkhäuser Boston. Translated from the Russian by Ian Porteous and Mark Reynolds. cited on page(s): 84, 384, 401
- Artin, Michael. 1969. Algebraization of formal moduli. I. Pages 21–71 of: *Global analysis (Papers in honor of K. Kodaira)*. Tokyo: University of Tokyo Press. cited on page(s): 131, 133, 363
- Artin, Michael. 1974. Algebraic construction of Brieskorn’s resolutions. *J. Algebra*, **29**, 330–348. cited on page(s): 21, 58
- Artin, Michael. 1976. *Deformations of singularities*. Bombay: Tata Institute. cited on page(s): 25, 84, 220, 238, 248, 361

- Artin, Michael. 1977. Coverings of the rational double points in characteristic p . Pages 11–22 of: *Complex analysis and algebraic geometry*. Tokyo: Iwanami Shoten. cited on page(s): 76
- Ascher, Kenneth, and Bejleri, Dori. 2019. Moduli of fibered surface pairs from twisted stable maps. *Math. Ann.*, **374**(1–2), 1007–1032. cited on page(s): 307
- Ascher, Kenneth, and Bejleri, Dori. 2021a. Moduli of double covers and degree one del Pezzo surfaces. *Eur. J. Math.*, **7**(2), 557–569. cited on page(s): 307
- Ascher, Kenneth, and Bejleri, Dori. 2021b. Moduli of weighted stable elliptic surfaces and invariance of log plurigenera. *Proc. Lond. Math. Soc. (3)*, **122**(5), 617–677. With an appendix by Giovanni Inchiostro. cited on page(s): 307
- Ascher, Kenneth, and Gallardo, Patricio. 2018. A generic slice of the moduli space of line arrangements. *Algebra Number Theory*, **12**(4), 751–778. cited on page(s): 307
- Ascher, Kenneth, and Molcho, Samouil. 2016. Logarithmic stable toric varieties and their moduli. *Algebr. Geom.*, **3**(3), 296–319. cited on page(s): 307
- Ascher, Kenneth, Dubé, Connor, Gershenson, Daniel, and Hou, Elaine. 2020. Enumerating Hassett’s wall and chamber decomposition of the moduli space of weighted stable curves. *Exp. Math.*, **29**(1), 36–53. cited on page(s): 307
- Ash, Avner, Mumford, David, Rapoport, Michael, and Tai, Yung-Sheng. 1975. *Smooth compactification of locally symmetric varieties*. Brookline, MA: Mathematical Science Press. Lie Groups: History, Frontiers and Applications, vol. IV. cited on page(s): 27
- Barlet, Daniel. 1975. Espace analytique réduit des cycles analytiques complexes compacts d’un espace analytique complexe de dimension finie. Pages 1–158. Lecture Notes in Math., vol. 482 of: *Fonctions de plusieurs variables complexes, II (Sém. François Norguet, 1974–1975)*. Berlin: Springer. cited on page(s): 131
- Barlet, Daniel, and Magnússon, Jón. 2020. *Cycles Analytiques Complexes II: L’espace des Cycles*. Cours Spécialisés, vol. 27. Paris: Société Mathématique de France. cited on page(s): 131
- Barth, W., Peters, C., and Van de Ven, A. 1984. *Compact complex surfaces*. Ergebnisse der Mathematik und ihrer Grenzgebiete (3), vol. 4. Berlin: Springer. cited on page(s): 31, 55
- Bejleri, Dori, and Inchiostro, Giovanni. 2021. Stable pairs with a twist and gluing morphisms for moduli of surfaces. *Selecta Math. (N.S.)*, **27**(3), Paper No. 40, 44. cited on page(s): 307
- Bernasconi, Fabio. 2018. Non-normal purely log terminal centres in characteristic $p \geq 3$. *Eur. J. Math.*, **5**(4), 1242–1251. cited on page(s): 339
- Bhatt, Bhargav, and de Jong, Aise Johan. 2014. Lefschetz for local Picard groups. *Ann. Sci. Éc. Norm. Supér. (4)*, **47**(4), 833–849. cited on page(s): 122, 123, 124
- Birkar, Caucher. 2017. The augmented base locus of real divisors over arbitrary fields. *Math. Ann.*, **369**, 905–921. cited on page(s): 426, 432
- Birkar, Caucher, Cascini, Paolo, Hacon, Christopher D., and McKernan, James. 2010. Existence of minimal models for varieties of log general type. *J. Amer. Math. Soc.*, **23**(2), 405–468. cited on page(s): 420
- Bombieri, Enrico. 1973. Canonical models of surfaces of general type. *Inst. Hautes Études Sci. Publ. Math.*, 171–219. cited on page(s): 222

- Bosch, Siegfried, Lütkebohmert, Werner, and Raynaud, Michel. 1990. *Néron models*. Ergebnisse der Mathematik und ihrer Grenzgebiete (3), vol. 21. Berlin: Springer. cited on page(s): 220, 265, 267, 335
- Boutot, Jean-François. 1978. *Schéma de Picard local*. Lecture Notes in Math., vol. 632. Berlin: Springer. cited on page(s): 168
- Brieskorn, Egbert. 1967/1968. Rationale Singularitäten komplexer Flächen. *Invent. Math.*, **4**, 336–358. cited on page(s): 77, 86, 249
- Bruns, Winfried, and Herzog, Jürgen. 1993. *Cohen–Macaulay rings*. Cambridge Studies in Advanced Mathematics, vol. 39. Cambridge: Cambridge University Press. cited on page(s): 377
- Buchsbaum, David A., and Eisenbud, David. 1977. Algebra structures for finite free resolutions, and some structure theorems for ideals of codimension 3. *Amer. J. Math.*, **99**(3), 447–485. cited on page(s): 84
- Campana, Frédéric, Koziarz, Vincent, and Păun, Mihai. 2012. Numerical character of the effectivity of adjoint line bundles. *Ann. Inst. Fourier (Grenoble)*, **62**(1), 107–119. cited on page(s): 169
- Catanese, Fabrizio. 1992. Chow varieties, Hilbert schemes and moduli spaces of surfaces of general type. *J. Algebraic Geom.*, **1**(4), 561–595. cited on page(s): 177, 260
- Cayley, Arthur. 1860. A new analytic representation of curves in space. *Quarterly J. Math.*, **3**, 225–236. cited on page(s): 9, 16, 127, 260, 283
- Cayley, Arthur. 1862. A new analytic representation of curves in space. *Quarterly J. Math.*, **5**, 81–86. cited on page(s): 9, 16, 127, 260, 283
- Cheltsov, Ivan. 2010. Factorial threefold hypersurfaces. *J. Algebraic Geom.*, **19**(4), 781–791. cited on page(s): 32
- Chiang-Hsieh, Hung-Jen, and Lipman, Joseph. 2006. A numerical criterion for simultaneous normalization. *Duke Math. J.*, **133**(2), 347–390. cited on page(s): 133
- Chow, Wei-Liang, and van der Waerden, Bartel Leendert. 1937. Zur algebraischen Geometrie. IX. *Math. Ann.*, **113**(1), 692–704. cited on page(s): 16
- Conrad, Brian. 2000. *Grothendieck duality and base change*. Lecture Notes in Math., vol. 1750. Berlin: Springer. cited on page(s): 28, 108, 110
- Dalbec, John, and Sturmfels, Bernd. 1995. Introduction to Chow forms. Pages 37–58 of: *Invariant methods in discrete and computational geometry (Curaçao, 1994)*. Dordrecht: Kluwer. cited on page(s): 177, 260
- de Fernex, Tommaso. 2005. Negative curves on very general blow-ups of \mathbb{P}^2 . Pages 199–207 of: *Projective varieties with unexpected properties*. Berlin: Walter de Gruyter. cited on page(s): 41
- de Fernex, Tommaso, and Hacon, Christopher D. 2009. Singularities on normal varieties. *Compositio Mathematica*, **145**(2), 393–414. cited on page(s): 435
- de Jong, A. Johan. 1996. Smoothness, semi-stability and alterations. *Inst. Hautes Études Sci. Publ. Math.*, 51–93. cited on page(s): 104
- de Jong, Theo, and van Straten, Duco. 1991. On the base space of a semi-universal deformation of rational quadruple points. *Ann. of Math.*, **134**(3), 653–678. cited on page(s): 390
- Deligne, P., and Mumford, D. 1969. The irreducibility of the space of curves of given genus. *Inst. Hautes Études Sci. Publ. Math.*, **63**, 75–109. cited on page(s): 20, 21, 219

- Dolgachev, Igor. 2003. *Lectures on invariant theory*. London Mathematical Society Lecture Note Series, vol. 296. Cambridge: Cambridge University Press. cited on page(s): 50, 55
- Donaldson, Simon. 2020. Fredholm topology and enumerative geometry: reflections on some words of Michael Atiyah. Pages 1–31 of: *Proceedings of the Gökova Geometry-Topology Conferences 2018/2019*. Somerville, MA: International Press. cited on page(s): 307
- Du Bois, Philippe. 1981. Complexe de de Rham filtré d'une variété singulière. *Bull. Soc. Math. France*, **109**(1), 41–81. cited on page(s): 105
- Du Bois, Philippe, and Jarraud, Pierre. 1974. Une propriété de commutation au changement de base des images directes supérieures du faisceau structural. *C. R. Acad. Sci. Paris Sér. A*, **279**, 745–747. cited on page(s): 105
- Du Val, P. 1934. On isolated singularities of surfaces which do not affect the conditions of adjunction I–II. *Proc. Camb. Phil. Soc.*, **30**, 453–465, 483–491. cited on page(s): 75
- Durfee, Alan H. 1979. Fifteen characterizations of rational double points and simple critical points. *Enseign. Math. (2)*, **25**(1–2), 131–163. cited on page(s): 76
- Earle, Clifford J. 1971. On the moduli of closed Riemann surfaces with symmetries. Pages 119–130. Ann. of Math. Studies, No. 66 of: *Advances in the theory of riemann surfaces (Proc. Conf., Stony Brook, NY, 1969)*. Princeton, NJ: Princeton University Press. cited on page(s): 62
- Eisenbud, David. 1995. *Commutative algebra: With a view toward algebraic geometry*. Graduate Texts in Mathematics, vol. 150. New York: Springer. cited on page(s): 273, 357, 366, 369, 371, 374, 379
- Eisenbud, David, and Harris, Joe. 1987. On varieties of minimal degree (a centennial account). Pages 3–13 of: *Algebraic geometry (Bowdoin, 1985, Brunswick, ME, 1985)*. Proc. Sympos. Pure Math., vol. 46. Providence, RI: American Mathematics Society. cited on page(s): 39
- Ekedahl, Torsten. 1988. Canonical models of surfaces of general type in positive characteristic. *Inst. Hautes Études Sci. Publ. Math.*, 97–144. cited on page(s): 222
- Ellingsrud, Geir, and Skjelbred, Tor. 1980. Profondeur d'anneaux d'invariants en caractéristique p . *Compositio Math.*, **41**(2), 233–244. cited on page(s): 340
- Esser, Louis, Totaro, Burt, and Wang, Chengxi. 2021. Varieties of general type with doubly exponential asymptotics. *arXiv e-prints*, Sept., arXiv:2109.13383. cited on page(s): 26
- Farkas, Gavril, and Morrison, Ian (eds). 2013. *Handbook of moduli. vols. I–III*. Advanced Lectures in Mathematics (ALM), vol. 24, 25, 26. Somerville, MA: International Press. cited on page(s): 21
- Filipazzi, Stefano, and Inchiostro, Giovanni. 2021. *Moduli of \mathbb{Q} -Gorenstein pairs and applications*. cited on page(s): 315, 320
- Fitting, Hans. 1936. Die Determinantenideale eines Moduls. *Jahresber. Deutsch. Math.-Verein.*, **46**, 195–228. cited on page(s): 273
- Franciosi, Marco, Pardini, Rita, and Rollenske, Sönke. 2015a. Computing invariants of semi-log-canonical surfaces. *Math. Z.*, **280**(3–4), 1107–1123. cited on page(s): 307
- Franciosi, Marco, Pardini, Rita, and Rollenske, Sönke. 2015b. Log-canonical pairs and Gorenstein stable surfaces with $K_X^2 = 1$. *Compos. Math.*, **151**(8), 1529–1542. cited on page(s): 307

- Franciosi, Marco, Pardini, Rita, and Rollenske, Sönke. 2017. Gorenstein stable surfaces with $K_X^2 = 1$ and $p_g > 0$. *Math. Nachr.*, **290**(5-6), 794–814. cited on page(s): 307
- Franciosi, Marco, Pardini, Rita, and Rollenske, Sönke. 2018. Gorenstein stable Godeaux surfaces. *Selecta Math. (N.S.)*, **24**(4), 3349–3379. cited on page(s): 307
- Franciosi, Marco, Pardini, Rita, Rana, Julie, and Rollenske, Sönke. 2022. I-surfaces with one T-singularity. *Boll. Unione Mat. Ital.*, **15**(1-2), 173–190. cited on page(s): 307
- Fujino, Osamu. 2000. Abundance theorem for semi log canonical threefolds. *Duke Math. J.*, **102**(3), 513–532. cited on page(s): 169
- Fujino, Osamu. 2007. What is log terminal? Pages 49–62 of: *Flips for 3-folds and 4-folds*. Oxford Lecture Ser. Math. Appl., vol. 35. Oxford: Oxford University Press. cited on page(s): 415
- Fujino, Osamu. 2014. Fundamental theorems for semi log canonical pairs. *Algebr. Geom.*, **1**(2), 194–228. cited on page(s): 169, 422
- Fujino, Osamu. 2017. *Foundations of the minimal model program*. MSJ Memoirs, vol. 35. Tokyo: Mathematical Society of Japan. cited on page(s): 320, 415, 417, 418, 422
- Fujino, Osamu. 2018. Semipositivity theorems for moduli problems. *Ann. of Math. (2)*, **187**(3), 639–665. cited on page(s): 27, 227
- Fujino, Osamu. 2022. *Minimal model program for projective morphisms between complex analytic spaces*. <https://arxiv.org/pdf/2201.11315.pdf>. cited on page(s): 411
- Fujino, Osamu, and Miyamoto, Keisuke. 2021. *Nakai–Moishezon ampleness criterion for real line bundles*. cited on page(s): 426, 432, 433
- Fujita, Takao. 1983. Vanishing theorems for semipositive line bundles. Pages 519–528 of: *Algebraic geometry (Tokyo/Kyoto, 1982)*. Lecture Notes in Math., vol. 1016. Berlin: Springer. cited on page(s): 432
- Fulger, Mihai, Kollár, János, and Lehmann, Brian. 2016. Volume and Hilbert function of \mathbb{R} -divisors. *Michigan Math. J.*, **65**(2), 371–387. cited on page(s): 383, 436
- Gieseker, D. 1977. Global moduli for surfaces of general type. *Invent. Math.*, **43**(3), 233–282. cited on page(s): 25
- Gongyo, Yoshinori. 2013. Abundance theorem for numerically trivial log canonical divisors of semi-log canonical pairs. *J. Algebraic Geom.*, **22**(3), 549–564. cited on page(s): 169
- Griffiths, Phillip, and Harris, Joseph. 1978. *Principles of algebraic geometry*. New York: Wiley-Interscience, John Wiley & Sons. Pure and Applied Mathematics. cited on page(s): 19, 222, 397
- Gross, Mark, Hacking, Paul, and Keel, Sean. 2015. Mirror symmetry for log Calabi-Yau surfaces I. *Publ. Math. Inst. Hautes Études Sci.*, **122**, 65–168. cited on page(s): 84
- Grothendieck, Alexander. 1960. Éléments de géométrie algébrique. I–IV. *Inst. Hautes Études Sci. Publ. Math.* cited on page(s): 112, 162, 355, 369, 376, 392, 398, 408
- Grothendieck, Alexander. 1962. *Fondements de la géométrie algébrique. [Extraits du Séminaire Bourbaki, 1957–1962.]*. Paris: Secrétariat mathématique. cited on page(s): 17, 127, 326, 335, 355
- Grothendieck, Alexander. 1967. *Local cohomology*. Lecture Notes in Math., vol. 41. Berlin: Springer. cited on page(s): 377

- Grothendieck, Alexander. 1968. *Cohomologie locale des faisceaux cohérents et théorèmes de Lefschetz locaux et globaux (SGA 2)*. Amsterdam: North-Holland Publishing. Augmenté d'un exposé par Michèle Raynaud, Séminaire de Géométrie Algébrique du Bois-Marie, 1962, *Advanced Studies in Pure Mathematics*, vol. 2. cited on page(s): 124, 346, 366, 379, 404
- Grothendieck, Alexander. 1971. *Revêtements étales et groupe fondamental*. Lecture Notes in Math., vol. 224. Heidelberg: Springer. cited on page(s): 163, 335, 395
- Gunning, Robert C., and Rossi, Hugo. 1965. *Analytic functions of several complex variables*. Englewood Cliffs, NJ: Prentice-Hall. cited on page(s): 397
- Haboush, William, and Lauritzen, Niels. 1993. Varieties of unseparated flags. Pages 35–57 of: *Linear algebraic groups and their representations (Los Angeles, CA, 1992)*. *Contemp. Math.*, vol. 153. Providence, RI: American Mathematics Society. cited on page(s): 339
- Hacking, Paul. 2004. Compact moduli of plane curves. *Duke Math. J.*, **124**(2), 213–257. cited on page(s): 307, 309
- Hacking, Paul. 2012. Compact moduli spaces of surfaces of general type. Pages 1–18 of: *Compact moduli spaces and vector bundles*. *Contemp. Math.*, vol. 564. Providence, RI: American Mathematics Society. cited on page(s): 307
- Hacking, Paul. 2013. Exceptional bundles associated to degenerations of surfaces. *Duke Math. J.*, **162**(6), 1171–1202. cited on page(s): 307
- Hacking, Paul. 2016. Compact moduli spaces of surfaces and exceptional vector bundles. Pages 41–67 of: *Compactifying moduli spaces*. *Adv. Courses Math. CRM Barcelona*. Birkhäuser/Springer. cited on page(s): 307
- Hacking, Paul, and Prokhorov, Yuri. 2010. Smoothable del Pezzo surfaces with quotient singularities. *Compos. Math.*, **146**(1), 169–192. cited on page(s): 307
- Hacking, Paul, Keel, Sean, and Tevelev, Jenia. 2006. Compactification of the moduli space of hyperplane arrangements. *J. Algebraic Geom.*, **15**(4), 657–680. cited on page(s): 307
- Hacking, Paul, Keel, Sean, and Tevelev, Jenia. 2009. Stable pair, tropical, and log canonical compactifications of moduli spaces of del Pezzo surfaces. *Invent. Math.*, **178**(1), 173–227. cited on page(s): 307
- Hacking, Paul, Tevelev, Jenia, and Urzúa, Giancarlo. 2017. Flipping surfaces. *J. Algebraic Geom.*, **26**(2), 279–345. cited on page(s): 307
- Hacon, Christopher D., and Xu, Chenyang. 2013. Existence of log canonical closures. *Invent. Math.*, **192**(1), 161–195. cited on page(s): 174, 323, 420
- Hacon, Christopher D., and Xu, Chenyang. 2016. On finiteness of B-representations and semi-log canonical abundance. Pages 361–377 of: *Minimal models and extremal rays (Kyoto, 2011)*. *Adv. Stud. Pure Math.*, vol. 70. Math. Soc. Japan [Tokyo]. cited on page(s): 169, 420
- Hacon, Christopher D., McKernan, James, and Xu, Chenyang. 2014. ACC for log canonical thresholds. *Annals of Math.*, **180**, 523–571. cited on page(s): 226
- Hacon, Christopher D., McKernan, James, and Xu, Chenyang. 2018. Boundedness of moduli of varieties of general type. *J. Eur. Math. Soc. (JEMS)*, **20**(4), 865–901. cited on page(s): 27, 225, 226
- Han, Jingjun, Liu, Jihao, and Shokurov, V. V. 2020. *ACC for minimal log discrepancies of exceptional singularities*. cited on page(s): 430

- Hartshorne, Robin. 1966. *Residues and duality*. Lecture notes of a seminar on the work of A. Grothendieck, given at Harvard 1963/64. With an appendix by P. Deligne. Lecture Notes in Math., No. 20. Berlin: Springer. cited on page(s): 28, 108
- Hartshorne, Robin. 1977. *Algebraic geometry*. New York: Springer. Graduate Texts in Mathematics, No. 52. cited on page(s): 10, 13, 15, 28, 108, 109, 127, 130, 134, 135, 239, 267, 317, 321, 324, 349, 368, 411, 433
- Hartshorne, Robin. 1986. Generalized divisors on Gorenstein curves and a theorem of Noether. *J. Math. Kyoto Univ.*, **26**(3), 375–386. cited on page(s): 152, 265
- Hartshorne, Robin. 2010. *Deformation theory*. Graduate Texts in Mathematics, vol. 257. New York: Springer. cited on page(s): 84, 220, 238, 361
- Hartshorne, Robin, and Polini, Claudia. 2015. Divisor class groups of singular surfaces. *Trans. Amer. Math. Soc.*, **367**(9), 6357–6385. cited on page(s): 152, 265
- Hassett, Brendan. 1999. Stable log surfaces and limits of quartic plane curves. *Manuscripta Math.*, **100**(4), 469–487. cited on page(s): 307
- Hassett, Brendan. 2000. Local stable reduction of plane curve singularities. *J. Reine Angew. Math.*, **520**, 169–194. cited on page(s): 307
- Hassett, Brendan. 2001. Stable limits of log surfaces and Cohen-Macaulay singularities. *J. Algebra*, **242**(1), 225–235. cited on page(s): 307
- Hassett, Brendan, and Hyeon, Donghoon. 2013. Log minimal model program for the moduli space of stable curves: the first flip. *Ann. of Math. (2)*, **177**(3), 911–968. cited on page(s): 60
- Hironaka, Heisuke. 1958. A note on algebraic geometry over ground rings: The invariance of Hilbert characteristic functions under the specialization process. *Illinois J. Math.*, **2**, 355–366. cited on page(s): 130, 403
- Hu, Zhi, and Zong, Runhong. 2020. *On Base Change of Local Stability in Positive Characteristics*. <https://arxiv.org/pdf/2001.04083.pdf>. cited on page(s): 74
- Humphreys, J. 1975. *Linear algebraic groups*. New York: Springer. cited on page(s): 85
- Huybrechts, Daniel, and Lehn, Manfred. 1997. *The geometry of moduli spaces of sheaves*. Aspects of Mathematics, E31. Braunschweig: Friedr. Vieweg & Sohn. cited on page(s): 356
- Iitaka, Shigeru. 1971. On D -dimensions of algebraic varieties. *J. Math. Soc. Japan*, **23**, 356–373. cited on page(s): 33
- Iitaka, Shigeru. 1972. Genera and classifications of algebraic varieties (in Japanese). *Sugaku*, **24**, 14–27. cited on page(s): 227
- Illusie, Luc. 1971. *Complexes cotangent et déformations. I–II*. Lecture Notes in Math., vols. 239, 283. Berlin: Springer. cited on page(s): 25
- Jung, Heinrich W. E. 1908. Darstellung der Funktionen eines algebraischen Körpers zweier unabhängigen Veränderlichen x, y in der Umgebung einer Stelle $x = a, y = b$. *J. Reine Angew. Math.*, **133**, 289–314. cited on page(s): 249
- Karu, Kalle. 2000. Minimal models and boundedness of stable varieties. *J. Algebraic Geom.*, **9**(1), 93–109. cited on page(s): 173
- Kawakita, Masayuki. 2007. Inversion of adjunction on log canonicity. *Invent. Math.*, **167**(1), 129–133. cited on page(s): 417
- Kawamata, Yujiro. 1985. Minimal models and the Kodaira dimension of algebraic fiber spaces. *J. Reine Angew. Math.*, **363**, 1–46. cited on page(s): 169

- Kawamata, Yujiro. 2013. On the abundance theorem in the case of numerical Kodaira dimension zero. *Amer. J. Math.*, **135**(1), 115–124. cited on page(s): 169
- Keel, Seán, and Mori, Shigefumi. 1997. Quotients by groupoids. *Ann. of Math. (2)*, **145**(1), 193–213. cited on page(s): 25, 227, 333
- Kempf, G., Knudsen, F. F., Mumford, D., and Saint-Donat, B. 1973. *Toroidal embeddings. I*. Lecture Notes in Math., vol. 339. Berlin: Springer. cited on page(s): 27, 104
- Klein, Felix, and Fricke, Robert. 1892. *Vorlesungen über die Theorie der elliptischen Modulfunktionen*. Leipzig: B. G. Teubner. cited on page(s): 19
- Knudsen, F. F. 1983. The projectivity of the moduli space of stable curves, II. *Math. Scand.*, **52**, 161–199. cited on page(s): 174
- Kodaira, K., and Spencer, D. C. 1958. On deformations of complex analytic structures. I, II. *Ann. of Math. (2)*, **67**, 328–466. cited on page(s): 36
- Kollár, János. 1990. Projectivity of complete moduli. *J. Differential Geom.*, **32**(1), 235–268. cited on page(s): 27, 227, 335
- Kollár, János. 1992a. Cone theorems and bug-eyed covers. *J. Algebraic Geom.*, **1**(2), 293–323. cited on page(s): 58
- Kollár, János (ed). 1992b. *Flips and abundance for algebraic threefolds*. Société Mathématique de France. Papers from the Second Summer Seminar on Algebraic Geometry, University of Utah, Salt Lake City, Utah, August 1991, Astérisque No. 211 (1992). cited on page(s): 417
- Kollár, János. 1995a. Flatness criteria. *J. Algebra*, **175**(2), 715–727. cited on page(s): 82, 396, 403
- Kollár, János. 1995b. *Shafarevich maps and automorphic forms*. M. B. Porter Lectures. Princeton, NJ: Princeton University Press. cited on page(s): 105
- Kollár, János. 1996. *Rational curves on algebraic varieties*. Ergebnisse der Mathematik und ihrer Grenzgebiete. 3. Folge., vol. 32. Berlin: Springer. cited on page(s): 16, 17, 127, 128, 129, 131, 132, 154, 156, 174, 176, 181, 202, 260, 326, 392, 404, 432
- Kollár, János. 1997. Quotient spaces modulo algebraic groups. *Ann. of Math. (2)*, **145**(1), 33–79. cited on page(s): 25, 227, 333
- Kollár, János. 1999. Effective Nullstellensatz for arbitrary ideals. *J. Eur. Math. Soc. (JEMS)*, **1**(3), 313–337. cited on page(s): 177, 260, 299, 300
- Kollár, János. 2006. Non-quasi-projective moduli spaces. *Ann. of Math. (2)*, **164**(3), 1077–1096. cited on page(s): 227
- Kollár, János. 2008a. *Hulls and husks*. arXiv:0805.0576. cited on page(s): 24, 343
- Kollár, János. 2008b. Is there a topological Bogomolov–Miyaoaka–Yau inequality? *Pure Appl. Math. Q.*, **4**(2, part 1), 203–236. cited on page(s): 43
- Kollár, János. 2010. Exercises in the birational geometry of algebraic varieties. Pages 495–524 of: *Analytic and algebraic geometry*. IAS/Park City Math. Ser., vol. 17. Providence, RI: American Mathematics Society. cited on page(s): 47
- Kollár, János. 2011a. A local version of the Kawamata-Viehweg vanishing theorem. *Pure Appl. Math. Q.*, **7**(4, Special Issue: In memory of Eckart Viehweg), 1477–1494. cited on page(s): 418
- Kollár, János. 2011b. Simultaneous normalization and algebra husks. *Asian J. Math.*, **15**(3), 437–449. cited on page(s): 133, 343, 400
- Kollár, János. 2011c. Two examples of surfaces with normal crossing singularities. *Sci. China Math.*, **54**(8), 1707–1712. cited on page(s): 46, 315

- Kollár, János. 2013a. Grothendieck–Lefschetz type theorems for the local Picard group. *J. Ramanujan Math. Soc.*, **28A**, 267–285. cited on page(s): 71, 123, 124, 188
- Kollár, János. 2013b. *Singularities of the minimal model program*. Cambridge Tracts in Mathematics, vol. 200. Cambridge: Cambridge University Press. With the collaboration of Sándor Kovács. cited on page(s): 6, 8, 9, 10, 34, 35, 38, 47, 66, 67, 68, 69, 72, 74, 76, 79, 80, 88, 89, 90, 91, 92, 97, 99, 102, 103, 104, 108, 141, 166, 167, 169, 173, 193, 214, 377, 384, 404, 405, 411, 414, 415, 417, 418, 419, 421, 422, 423, 426, 431, 434, 435
- Kollár, János. 2014. Semi-normal log centres and deformations of pairs. *Proc. Edinb. Math. Soc. (2)*, **57**(1), 191–199. cited on page(s): 119, 415
- Kollár, János. 2015. *How much of the Hilbert function do we really need to know?* arXiv:1503.08694. cited on page(s): 186
- Kollár, János. 2016a. Maps between local Picard groups. *Algebr. Geom.*, **3**(4), 461–495. cited on page(s): 122, 124, 168, 188
- Kollár, János. 2016b. Sources of log canonical centers. Pages 29–48 of: *Minimal models and extremal rays (Kyoto, 2011)*. Adv. Stud. Pure Math., vol. 70. Math. Soc. Japan [Tokyo]. cited on page(s): 423
- Kollár, János. 2016c. Variants of normality for Noetherian schemes. *Pure Appl. Math. Q.*, **12**(1), 1–31. cited on page(s): 405
- Kollár, János. 2017. Coherence of local and global hulls. *Methods Appl. Anal.*, **24**(1), 63–70. cited on page(s): 344, 345, 376
- Kollár, János. 2018a. Log-plurigenera in stable families. *Peking Math. J.*, **1**(1), 81–107. cited on page(s): 119, 121, 233, 234, 421, 436
- Kollár, János. 2018b. Log-plurigenera in stable families of surfaces. *Peking Math. J.*, **1**(1), 109–124. cited on page(s): 234
- Kollár, János. 2019. *Families of divisors*. arXiv:1910.00937. cited on page(s): 24, 221
- Kollár, János. 2021a. Deformations of varieties of general type. *Milan J. Math.*, **89**(2), 345–354. cited on page(s): 36, 42
- Kollár, János. 2021b. Mumford’s influence on the moduli theory of algebraic varieties. *Pure Appl. Math. Q.*, **17**(2), 619–647. cited on page(s): 14, 19
- Kollár, János. 2022. *Families of stable 3-folds in positive characteristic*. cited on page(s): 23, 69, 339
- Kollár, János, and Kovács, Sándor J. 2010. Log canonical singularities are Du Bois. *J. Amer. Math. Soc.*, **23**(3), 791–813. cited on page(s): 27, 105, 107, 108, 415
- Kollár, János, and Kovács, Sándor J. 2020. Deformations of log canonical and F -pure singularities. *Algebr. Geom.*, **7**(6), 758–780. cited on page(s): 105, 107, 108, 245
- Kollár, János, and Matsusaka, Teruhisa. 1983. Riemann–Roch type inequalities. *Amer. J. Math.*, **105**(1), 229–252. cited on page(s): 323
- Kollár, János, and Mori, Shigefumi. 1992. Classification of three-dimensional flips. *J. Amer. Math. Soc.*, **5**(3), 533–703. cited on page(s): 36, 43, 168
- Kollár, János, and Mori, Shigefumi. 1998. *Birational geometry of algebraic varieties*. Cambridge Tracts in Mathematics, vol. 134. Cambridge: Cambridge University Press. With the collaboration of C. H. Clemens and A. Corti; translated from the 1998 Japanese original. cited on page(s): 10, 11, 28, 85, 97, 108, 122, 172, 315, 411, 413, 414, 417, 419, 420, 422, 432, 436

- Kollár, János, and Shepherd-Barron, N. I. 1988. Threefolds and deformations of surface singularities. *Invent. Math.*, **91**(2), 299–338. cited on page(s): 8, 22, 24, 141, 191, 206, 207, 218, 219, 230, 306
- Kollár, János, Smith, Karen E., and Corti, Alessio. 2004. *Rational and nearly rational varieties*. Cambridge Studies in Advanced Mathematics, vol. 92. Cambridge: Cambridge University Press. cited on page(s): 61
- Kontsevich, Maxim, and Tschinkel, Yuri. 2019. Specialization of birational types. *Invent. Math.*, **217**, 415–432. cited on page(s): 31
- Kovács, Sándor J. 1999. Rational, log canonical, Du Bois singularities: On the conjectures of Kollár and Steenbrink. *Compositio Math.*, **118**(2), 123–133. cited on page(s): 105
- Kovács, Sándor J. 2011. Irrational centers. *Pure Appl. Math. Q.*, **7**(4, Special Issue: In memory of Eckart Viehweg), 1495–1515. cited on page(s): 418
- Kovács, Sándor J. 2018. Non-Cohen–Macaulay canonical singularities. Pages 251–259 of: *Local and global methods in algebraic geometry*. Contemp. Math., vol. 712. Providence, RI: American Mathematics Society. cited on page(s): 339
- Kovács, Sándor J., and Patakfalvi, Zsolt. 2017. Projectivity of the moduli space of stable log-varieties and subadditivity of log-Kodaira dimension. *J. Amer. Math. Soc.*, **30**(4), 959–1021. cited on page(s): 27, 227
- Kovács, Sándor J., and Schwede, Karl. 2016. Inversion of adjunction for rational and Du Bois pairs. *Algebra Number Theory*, **10**(5), 969–1000. cited on page(s): 313
- Kuipers, L., and Niederreiter, H. 1974. *Uniform distribution of sequences*. Pure and Applied Mathematics. New York: Wiley-Interscience. cited on page(s): 430
- Kunz, Ernst. 1976. On Noetherian rings of characteristic p . *Amer. J. Math.*, **98**(4), 999–1013. cited on page(s): 177
- Laufer, Henry B. 1977. On minimally elliptic singularities. *Amer. J. Math.*, **99**(6), 1257–1295. cited on page(s): 83
- Laumon, Gérard, and Moret-Bailly, Laurent. 2000. *Champs algébriques*. Ergebnisse der Mathematik und ihrer Grenzgebiete. 3. Folge., vol. 39. Berlin: Springer. cited on page(s): 61, 363, 364
- Lauritzen, Niels. 1996. Embeddings of homogeneous spaces in prime characteristics. *Amer. J. Math.*, **118**(2), 377–387. cited on page(s): 339
- Lazarsfeld, Robert. 2004. *Positivity in algebraic geometry. I–II*. Ergebnisse der Mathematik und ihrer Grenzgebiete. 3. Folge., vol. 48–49. Berlin: Springer. cited on page(s): 33, 171, 210, 324, 380, 426, 432, 433, 434
- Lee, Yongnam, and Nakayama, Noboru. 2018. Grothendieck duality and \mathbb{Q} -Gorenstein morphisms. *Publ. Res. Inst. Math. Sci.*, **54**(3), 517–648. cited on page(s): 74, 403
- Lee, Yongnam, and Park, Jongil. 2007. A simply connected surface of general type with $p_g = 0$ and $K^2 = 2$. *Invent. Math.*, **170**(3), 483–505. cited on page(s): 42
- Lesieutre, John. 2014. The diminished base locus is not always closed. *Compos. Math.*, **150**(10), 1729–1741. cited on page(s): 197, 322
- Lieberman, D., and Mumford, D. 1975. Matsusaka’s big theorem. Pages 513–530 of: *Algebraic geometry (Humboldt State University, Arcata, CA, 1974)*. Proc. Sympos. Pure Math., vol. 29. Providence, RI: Amer. Math. Soc. cited on page(s): 323
- Lin, Yinbang. 2015 (Dec.). *Moduli spaces of stable pairs*. arxiv:1512.03091. cited on page(s): 353

- Lipman, Joseph. 1969. On the Jacobian ideal of the module of differentials. *Proc. Amer. Math. Soc.*, **21**, 422–426. cited on page(s): 273
- Liu, Wenfei, and Rollenske, Sönke. 2014. Pluricanonical maps of stable log surfaces. *Adv. Math.*, **258**, 69–126. cited on page(s): 307
- Looijenga, E. J. N. 1984. *Isolated singular points on complete intersections*. London Mathematical Society Lecture Note Series, vol. 77. Cambridge: Cambridge University Press. cited on page(s): 84, 248
- Looijenga, Eduard, and Wahl, Jonathan. 1986. Quadratic functions and smoothing surface singularities. *Topology*, **25**(3), 261–291. cited on page(s): 84
- Luo, Zhao Hua. 1987. Kodaira dimension of algebraic function fields. *Amer. J. Math.*, **109**(4), 669–693. cited on page(s): 35
- Lyu, Shiji, and Murayama, Takumi. 2022. *The relative minimal model program for excellent algebraic spaces and analytic spaces in equal characteristic zero*. <https://arxiv.org/pdf/2209.08732.pdf>. cited on page(s): 411, 420
- Matsumura, Hideyuki. 1986. *Commutative ring theory*. Cambridge Studies in Advanced Mathematics, vol. 8. Cambridge: Cambridge University Press. Translated from the Japanese by M. Reid. cited on page(s): 366, 367, 392, 394
- Matsusaka, Teruhisa. 1964. *Theory of Q -varieties*. Math. Soc. Japan [Tokyo]. cited on page(s): 25
- Matsusaka, Teruhisa. 1972. Polarized varieties with a given Hilbert polynomial. *Amer. J. Math.*, **94**, 1027–1077. cited on page(s): 27, 323, 326, 432
- Matsusaka, Teruhisa, and Mumford, David. 1964. Two fundamental theorems on deformations of polarized varieties. *Amer. J. Math.*, **86**, 668–684. cited on page(s): 31, 424
- Milnor, John Willard. 1963. *Morse theory*. Based on lecture notes by M. Spivak and R. Wells. Annals of Mathematics Studies, No. 51. Princeton, NJ: Princeton University Press. cited on page(s): 384
- Mori, Shigefumi. 1975. On a generalization of complete intersections. *J. Math. Kyoto Univ.*, **15**(3), 619–646. cited on page(s): 52
- Mori, Shigefumi. 1987. Classification of higher-dimensional varieties. Pages 269–331 of: *Algebraic geometry (Bowdoin, 1985, Brunswick, Maine, 1985)*. Proc. Sympos. Pure Math., vol. 46. Providence, RI: Amer. Math. Soc. cited on page(s): 227
- Mumford, David. 1961. The topology of normal singularities of an algebraic surface and a criterion for simplicity. *Inst. Hautes Études Sci. Publ. Math.*, 5–22. cited on page(s): 434
- Mumford, David. 1965. *Geometric invariant theory*. Ergebnisse der Mathematik und ihrer Grenzgebiete, Neue Folge, Band 34. Berlin: Springer. cited on page(s): 19, 21, 25, 38, 50, 55, 333
- Mumford, David. 1966. *Lectures on curves on an algebraic surface*. With a section by G. M. Bergman. Annals of Mathematics Studies, No. 59. Princeton, NJ: Princeton University Press. cited on page(s): 13, 17, 133, 356
- Mumford, David. 1970. *Abelian varieties*. Tata Inst. Fund. Res. Studies in Math., No. 5. Bombay: Tata Institute of Fundamental Research. cited on page(s): 135
- Mumford, David. 1977. Stability of projective varieties. *Enseignement Math. (2)*, **23**(1–2), 39–110. cited on page(s): 22

- Mumford, David. 1978. Some footnotes to the work of C. P. Ramanujam. Pages 247–262 of: *C. P. Ramanujam: a tribute*. Tata Inst. Fund. Res. Studies in Math., vol. 8. Berlin: Springer. cited on page(s): 207
- Nagata, Masayoshi. 1955. On the normality of the Chow variety of positive 0-cycles of degree m in an algebraic variety. *Mem. Coll. Sci. Univ. Kyoto. Ser. A. Math.*, **29**, 165–176. cited on page(s): 131
- Nagata, Masayoshi. 1962. *Local rings*. Interscience Tracts in Pure and Applied Mathematics, No. 13. London: Wiley Interscience. cited on page(s): 392
- Nakayama, Noboru. 1986. Invariance of the plurigenera of algebraic varieties under minimal model conjectures. *Topology*, **25**(2), 237–251. cited on page(s): 190
- Nakayama, Noboru. 1987. The lower semicontinuity of the plurigenera of complex varieties. Pages 551–590 of: *Algebraic geometry, Sendai, 1985*. Adv. Stud. Pure Math., vol. 10. Amsterdam: North-Holland. cited on page(s): 190
- Nakayama, Noboru. 2004. *Zariski-decomposition and abundance*. MSJ Memoirs, vol. 14. Math. Soc. Japan [Tokyo]. cited on page(s): 36
- Odaka, Yuji, and Xu, Chenyang. 2012. Log-canonical models of singular pairs and its applications. *Math. Res. Lett.*, **19**(2), 325–334. cited on page(s): 214, 421
- Oguiso, Keiji. 2017. Isomorphic quartic K3 surfaces in the view of Cremona and projective transformations. *Taiwanese J. Math.*, **21**(3), 671–688. cited on page(s): 51
- Olsson, Martin. 2016. *Algebraic spaces and stacks*. American Mathematical Society Colloquium Publications, vol. 62. Providence, RI: Amer. Math. Soc. cited on page(s): 333
- Ottem, John Christian, and Schreieder, Stefan. 2020. On deformations of quintic and septic hypersurfaces. *J. Math. Pures Appl.*, **135**, 140–158. cited on page(s): 52
- Pan, L., and Shen, J. 2013 (Sept.). *An example on volumes jumping over Zariski dense set*. arxiv:1309.7535. cited on page(s): 197
- Pandharipande, Rahul, and Thomas, Richard. P. 2009. Curve counting via stable pairs in the derived category. *Invent. Math.*, **178**(2), 407–447. cited on page(s): 343
- Pandharipande, Rahul. 2018a. 2018 ICM plenary lecture, Rio de Janeiro. cited on page(s): 21
- Pandharipande, Rahul. 2018b. *Geometry of the moduli space of curves*. slides of the 2018ICM lecture, <https://people.math.ethz.ch/~rahul/Rio2.pdf>. cited on page(s): 21
- Park, Heesang, Park, Jongil, and Shin, Dongsoo. 2009a. A simply connected surface of general type with $p_g = 0$ and $K^2 = 3$. *Geom. Topol.*, **13**(2), 743–767. cited on page(s): 42
- Park, Heesang, Park, Jongil, and Shin, Dongsoo. 2009b. A simply connected surface of general type with $p_g = 0$ and $K^2 = 4$. *Geom. Topol.*, **13**(3), 1483–1494. cited on page(s): 42
- Patakfalvi, Zsolt. 2013. Base change behavior of the relative canonical sheaf related to higher dimensional moduli. *Algebra Number Theory*, **7**(2), 353–378. cited on page(s): 96, 108
- Patakfalvi, Zsolt. 2014. Semi-positivity in positive characteristics. *Ann. Sci. Éc. Norm. Supér. (4)*, **47**(5), 991–1025. cited on page(s): 227
- Patakfalvi, Zsolt. 2017. *On the projectivity of the moduli space of stable surfaces in characteristic $p > 5$* . arxiv:1710.03818. cited on page(s): 227

- Piene, Ragni, and Schlessinger, Michael. 1985. On the Hilbert scheme compactification of the space of twisted cubics. *Amer. J. Math.*, **107**(4), 761–774. cited on page(s): 302
- Pinkham, Henry C. 1974. *Deformations of algebraic varieties with G_m action*. Paris: Société Mathématique de France. Astérisque, No. 20. cited on page(s): 84, 87
- Pinkham, Henry C. 1977. Deformations of quotient surface singularities. Pages 65–67 of: *Several complex variables Part 1 (Williams Coll., Williamstown, MA, 1975)*. Proc. Sympos. Pure Math., vol. XXX. Providence, RI: American Mathematics Society. cited on page(s): 253
- Ramanujam, Chakravarthi Padmanabhan. 1963. Appendix to: Quotient space by an abelian variety, by C. S. Seshadri. *Math. Ann.*, **152**, 185–194. cited on page(s): 147, 398
- Rana, Julie. 2017. A boundary divisor in the moduli spaces of stable quintic surfaces. *Internat. J. Math.*, **28**(4), 1750021, 61. cited on page(s): 307
- Rana, Julie, and Urzúa, Giancarlo. 2019. Optimal bounds for T-singularities in stable surfaces. *Adv. Math.*, **345**, 814–844. cited on page(s): 307
- Raynaud, Michel. 1970. Spécialisation du foncteur de Picard. *Inst. Hautes Études Sci. Publ. Math.*, 27–76. cited on page(s): 324, 325
- Raynaud, Michel, and Gruson, Laurent. 1971. Critères de platitude et de projectivité. Techniques de “platification” d’un module. *Invent. Math.*, **13**, 1–89. cited on page(s): 388, 389
- Reid, Miles. 1980. Canonical 3-folds. Pages 273–310 of: *Journées de Géométrie Algébrique d’Angers, Juillet 1979/Algebraic Geometry, Angers, 1979*. Alphen aan den Rijn: Sijthoff & Noordhoff. cited on page(s): 34, 35, 419
- Riemenschneider, Oswald. 1974. Deformationen von Quotientensingularitäten (nach zyklischen Gruppen). *Math. Ann.*, **209**, 211–248. cited on page(s): 250, 253
- Rosenlicht, Maxwell. 1954. Generalized Jacobian varieties. *Ann. of Math. (2)*, **59**, 505–530. cited on page(s): 265
- Saito, Kyoji. 1974. Einfach-elliptische Singularitäten. *Invent. Math.*, **23**, 289–325. cited on page(s): 83
- Samuel, Pierre. 1962. Sur une conjecture de Grothendieck. *C. R. Acad. Sci. Paris Sér. A-B*, **255**, 3101–3103. <https://arxiv.org/pdf/2204.04400.pdf>. cited on page(s): 147, 398
- Sato, Kenta, and Takagi, Shunsuke. 2022. *Deformations of log terminal and semi log canonical singularities*. cited on page(s): 208
- Schlessinger, Michael. 1971. Rigidity of quotient singularities. *Invent. Math.*, **14**, 17–26. cited on page(s): 239, 250
- Schubert, David. 1991. A new compactification of the moduli space of curves. *Compositio Math.*, **78**(3), 297–313. cited on page(s): 60
- Sernesi, Edoardo. 2006. *Deformations of algebraic schemes*. Grundlehren der Mathematischen Wissenschaften, vol. 334. Berlin: Springer. cited on page(s): 17, 25, 127, 128, 220, 326, 355
- Serre, Jean-Pierre. 1955–6. Géométrie algébrique et géométrie analytique. *Ann. Inst. Fourier, Grenoble*, **6**, 1–42. cited on page(s): 105
- Serre, Jean-Pierre. 1959. *Groupes algébriques et corps de classes*. Publications de l’institut de mathématique de l’université de Nancago, VII. Paris: Hermann. cited on page(s): 174, 265

- Seshadri, C. S. 1962/1963. Some results on the quotient space by an algebraic group of automorphisms. *Math. Ann.*, **149**, 286–301. cited on page(s): 333
- Seshadri, C. S. 1972. Quotient spaces modulo reductive algebraic groups. *Ann. of Math.* (2), **95**, 511–556; errata, *ibid.* (2) **96** (1972), 599. cited on page(s): 333
- Seshadri, C. S. 1975. Theory of moduli. Pages 263–304 of: *Algebraic geometry (Humboldt State University, Arcata, CA, 1974)*. Proc. Sympos. Pure Math., vol. 29. Providence, RI: American Mathematics Society. cited on page(s): 361
- Severi, Francesco. 1947. *Funzioni quasi abeliane*. Pontificiae Academiae Scientiarum Scripta Varia, v. 4. Vaitcan City: Publisher unknown. cited on page(s): 265
- Shafarevich, Igor R. 1974. *Basic algebraic geometry*. Die Grundlehren der mathematischen Wissenschaften, Band 213. New York: Springer. cited on page(s): 19, 28, 337
- Shimada, Ichiro, and Shioda, Tetsuji. 2017. On a smooth quartic surface containing 56 lines which is isomorphic as a $K3$ surface to the Fermat quartic. *Manuscripta Math.*, **153**(1-2), 279–297. cited on page(s): 51
- Shimura, Goro. 1972. On the field of rationality for an abelian variety. *Nagoya Math. J.*, **45**, 167–178. cited on page(s): 62
- Shokurov, V. V. 1996. 3-fold log models. *J. Math. Sci.*, **81**(3), 2667–2699. cited on page(s): 432
- Siegel, Carl Ludwig. 1969. *Topics in complex function theory. I–III*. Translated from the original German. London: Wiley-Interscience. cited on page(s): 19
- Simonetti, Angelica. 2022. $\mathbb{Z}/2\mathbb{Z}$ -equivariant smoothings of cusp singularities. <https://arxiv.org/pdf/2201.02871.pdf>. cited on page(s): 86
- Simpson, Carlos. 1993. Subspaces of moduli spaces of rank one local systems. *Ann. Sci. École Norm. Sup. (4)*, **26**(3), 361–401. cited on page(s): 169
- Siu, Yum-Tong. 1998. Invariance of plurigenera. *Invent. Math.*, **134**(3), 661–673. cited on page(s): 36
- Smyth, David Ishii. 2013. Towards a classification of modular compactifications of $M_{g,n}$. *Invent. Math.*, **192**(2), 459–503. cited on page(s): 60
- Stacks, Authors. 2022. *Stacks Project*. <http://stacks.math.columbia.edu>. cited on page(s): 49, 75, 108, 113, 124, 199, 333, 335, 337, 344, 366, 367, 375, 389, 392, 406, 408, 412
- Steenbrink, J. H. M. 1983. Mixed Hodge structures associated with isolated singularities. Pages 513–536 of: *Singularities, Part 2 (Humboldt State Univ., Arcata, Calif., 1981)*. Proc. Sympos. Pure Math., vol. 40. Providence, RI: American Mathematics Society. cited on page(s): 105
- Stern, Arié, and Urzúa, Giancarlo. 2016. KSBA surfaces with elliptic quotient singularities, $\pi_1 = 1$, $p_g = 0$, and $K^2 = 1, 2$. *Israel J. Math.*, **214**(2), 651–673. cited on page(s): 307
- Stevens, Jan. 1988. On canonical singularities as total spaces of deformations. *Abh. Math. Sem. Univ. Hamburg*, **58**, 275–283. cited on page(s): 244
- Stevens, Jan. 1998. Degenerations of elliptic curves and equations for cusp singularities. *Math. Ann.*, **311**(2), 199–222. cited on page(s): 84
- Stevens, Jan. 2013. The versal deformation of cyclic quotient singularities. Pages 163–201 of: *Deformations of surface singularities*. Bolyai Soc. Math. Stud., vol. 23. Budapest: János Bolyai Math. Soc, Budapest. cited on page(s): 250

- Teichmüller, Oswald. 1944. Veränderliche Riemannsche Flächen. *Deutsche Math.*, **7**, 344–359. cited on page(s): 19
- Thompson, Alan. 2014. Degenerations of K3 surfaces of degree two. *Trans. Amer. Math. Soc.*, **366**(1), 219–243. cited on page(s): 307
- Totaro, Burt. 2019. The failure of Kodaira vanishing for Fano varieties, and terminal singularities that are not Cohen-Macaulay. *J. Algebraic Geom.*, **28**(4), 751–771. cited on page(s): 339, 340
- Tziolas, Nikolaos. 2009. \mathbb{Q} -Gorenstein deformations of nonnormal surfaces. *Amer. J. Math.*, **131**(1), 171–193. cited on page(s): 307
- Tziolas, Nikolaos. 2010. Smoothings of schemes with nonisolated singularities. *Michigan Math. J.*, **59**(1), 25–84. cited on page(s): 307
- Tziolas, Nikolaos. 2017. Automorphisms of smooth canonically polarized surfaces in positive characteristic. *Adv. Math.*, **310**, 235–289. cited on page(s): 307
- Tziolas, Nikolaos. 2022. Vector fields on canonically polarized surfaces. *Math. Z.*, **300**(3), 2837–2883. cited on page(s): 307
- Urzúa, Giancarlo. 2016a. \mathbb{Q} -Gorenstein smoothings of surfaces and degenerations of curves. *Rend. Semin. Mat. Univ. Padova*, **136**, 111–136. cited on page(s): 307
- Urzúa, Giancarlo. 2016b. Identifying neighbors of stable surfaces. *Ann. Sc. Norm. Super. Pisa Cl. Sci. (5)*, **16**(4), 1093–1122. cited on page(s): 307
- Urzúa, Giancarlo, and Yáñez, José Ignacio. 2018. Characterization of Kollár surfaces. *Algebra Number Theory*, **12**(5), 1073–1105. cited on page(s): 43
- Vakil, Ravi. 2006. Murphy's law in algebraic geometry: badly-behaved deformation spaces. *Invent. Math.*, **164**(3), 569–590. cited on page(s): 25
- van Opstall, Michael A. 2005. Moduli of products of curves. *Arch. Math. (Basel)*, **84**(2), 148–154. cited on page(s): 307
- van Opstall, Michael A. 2006a. Stable degenerations of surfaces isogenous to a product of curves. *Proc. Amer. Math. Soc.*, **134**(10), 2801–2806. cited on page(s): 307
- van Opstall, Michael A. 2006b. Stable degenerations of symmetric squares of curves. *Manuscripta Math.*, **119**(1), 115–127. cited on page(s): 307
- Viehweg, Eckart. 1995. *Quasi-projective moduli for polarized manifolds*. Ergebnisse der Mathematik und ihrer Grenzgebiete (3), vol. 30. Berlin: Springer. cited on page(s): 24, 25, 218, 234
- von Essen, Hartwig. 1990. Nonflat deformations of modules and isolated singularities. *Math. Ann.*, **287**(3), 413–427. cited on page(s): 239
- Wahl, Jonathan M. 1980. Elliptic deformations of minimally elliptic singularities. *Math. Ann.*, **253**(3), 241–262. cited on page(s): 248, 256
- Wahl, Jonathan M. 1981. Smoothings of normal surface singularities. *Topology*, **20**(3), 219–246. cited on page(s): 248
- Wandel, Malte. 2015. Moduli spaces of semistable pairs in Donaldson-Thomas theory. *Manuscripta Math.*, **147**(3-4), 477–500. cited on page(s): 353
- Wang, Xiaowei, and Xu, Chenyang. 2014. Nonexistence of asymptotic GIT compactification. *Duke Math. J.*, **163**(12), 2217–2241. cited on page(s): 22, 25
- Weil, André. 1946. *Foundations of Algebraic Geometry*, vol. 29. New York: American Mathematical Society. cited on page(s): 61
- Xu, Chenyang. 2020. *K-stability of Fano varieties: an algebro-geometric approach*. arxiv:2011.10477. cited on page(s): 28
- Yasuda, Takehiko. 2019. Discrepancies of p -cyclic quotient varieties. *J. Math. Sci. Univ. Tokyo*, **26**(1), 1–14. cited on page(s): 340