

# A rough SABR formula

MASAAKI FUKASAWA<sup>1</sup>, JIM GATHERAL<sup>2</sup>

<sup>1</sup> *Graduate School of Engineering Science, Osaka University, Japan.*

*E-mail address:* fukasawa@sigmath.es.osaka-u.ac.jp

*URL:* <http://www.sigmath.es.osaka-u.ac.jp/~fukasawa>

<sup>2</sup> *Baruch College, City University of New York, USA.*

Following an approach originally suggested by Balland [1] in the context of the SABR model [3], we derive an ODE that is satisfied by normalized volatility smiles for short maturities under a *rough SABR model* - a rough volatility extension of the SABR model that also extends the rough Bergomi model [2]. We solve this ODE numerically and further derive a very accurate closed-form approximation to the numerical solution that we dub the *rough SABR formula*.

## References

- [1] Philippe Balland. Forwrd smile. Presentation at Global Derivatives, Paris, September 2006.
- [2] Christian Bayer, Peter Friz, and Jim Gatheral. Pricing under rough volatility. *Quantitative Finance*, 16(6):887–904, 2016.
- [3] Patrick S Hagan, Deep Kumar, Andrew S Lesniewski, and Diana E Woodward. Managing smile risk. *Wilmott Magazine*, pages 84–108, 2002.