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**Victoria Gitman\*** ([vgitman@gmail.com](mailto:vgitman@gmail.com)), CUNY Graduate Center, Mathematics Department,  
365 5th Avenue, New York, NY 10016. *Ground model definability in ZF.*

Laver, and independently Woodin, showed that a ground model is always definable in a set-forcing extension. This result gave rise to the very fruitful research topic of set theoretic geology initiated by Gunter Fuchs, Joel Hamkins, and Jonas Reitz. All known proofs of ground model definability rely heavily on the Axiom of Choice, and so it has been a long-standing open question whether ground model definability holds in ZF. With Johnstone, we adapted Laver's argument to the choiceless setting to show that a universe satisfying  $ZF + DC_\delta$ , for a cardinal  $\delta$ , is definable in its set-forcing extensions by partial orders admitting a gap at  $\delta$  - having the form  $\mathbb{R} * \dot{\mathbb{Q}}$ , where  $\mathbb{R}$  has size  $< \delta$  and  $\dot{\mathbb{Q}}$  is forced to be  $\leq \delta$ -strategically closed. Recently, Usuba showed that if a ZF-universe has a proper class of Löwenheim-Skolem cardinals, a notion he introduces, then it is definable in its set-forcing extensions. Many naturally arising ZF-universes, such as symmetric models and universes over which choice is forceable, in particular  $L(\mathbb{R})$ , have a proper class of Löwenheim-Skolem cardinals. In the talk, I will survey these partial results. (Received September 12, 2019)