AUT Journal of Mathematics and Computing

AUT J. Math. Comput., 7(4) (2026) 391-397
https://doi.org/10.22060/AJMC.2024.23561.1266

Original Article

Waldschmidt constant of some classes of hypergraphs

Iman Jahani, Shamila Bayati*

Department of Mathematics and Computer Science, Amirkabir University of Technology (Tehran Polytechnic), Tehran, Iran

ABSTRACT: In this paper, we present a formula for the Waldschmidt constant of edge ideals of some classes of hypergraphs. We also show that if G is a simple graph with binomial edge ideal J_G, then the Waldschmidt constant of J_G is always 2. Furthermore, the symbolic defect of umbrella hypergraphs is presented.

Review History:

Received:30 September 2024
Revised:12 October 2024
Accepted:14 October 2024
Available Online:01 October 2026

Keywords:

Edge ideal
Hyperstar
Symbolic defect
Symbolic power
Waldschmidt constant

MSC (2020):

13F20; 05E40; 13A15

1. Introduction

Let I be an ideal of a Noetherian ring, and $\mathfrak{p}_1, \ldots, \mathfrak{p}_r$ be its minimal primes. Then the m-th symbolic power of I is defined to be $I^{(m)} = \mathfrak{q}_1 \cap \cdots \cap \mathfrak{q}_r$ where $\mathfrak{q}_i$ is the $\mathfrak{p}_i$-primary component of I^m. Studying differences between symbolic and ordinary powers has been an active area of research for several decades in various fields of mathematics. An interesting invariant to compare symbolic and ordinary powers of a homogeneous ideal is the Waldschmidt constant which determines asymptotic behavior of minimal degrees of the symbolic powers. While it is hard to compute the Waldschmidt constant of an ideal I in general, it is shown in [2, Theorem 3.2] that the Waldschmidt constant can be computed by solving a linear program constructed from the primary decomposition of I when I is a squarefree monomial ideal of a polynomial ring. See [1, 2, 3, 4, 5, 10, 13, 14, 18] for several classes of ideals in the context of combinatorial commutative algebra whose Waldschmidt constant is computed. In this paper, we present a formula for the Waldschmidt constant of the edge ideal of an umbrella hypergraph and a wheel hypergraph in Theorem 3.2 and Theorem 3.7. It turns out in Theorem 3.8 that the Waldschmidt constant of the binomial edge ideal of a graph is always two.

Another relatively new invariant to compare the m-th symbolic and ordinary power of an ideal is the m-th symbolic defect first introduced in [8]. The asymptotic growth rate of symbolic defect of monomial ideals is considered in [16]. Symbolic defect of the edge ideal of a cycle graph is given in [12]. We present symbolic defect of the edge ideal of an umbrella hypergraph in Theorem 4.2.

* *Corresponding author.*

E-mail addresses: `imanjahani@aut.ac.ir` (I. Jahani), `shamilabayati@gmail.com` (Sh. Bayati)

2. Preliminaries

Definition 2.1. *A hypergraph is a pair (V, E) where V is a set and E is a collection of subsets of V. V is called the vertex set and E is called the hyperedge set of $\mathcal{H}$. A hypergraph $\mathcal{H}$ is called k-uniform if every edge of $\mathcal{H}$ has cardinality k.*

Definition 2.2. *Let $\mathcal{H} = (V, E)$ be a hypergraph and C be a nonempty subset of V. The hypergraph $\mathcal{H}$ is called a hyperstar with center C if*

$$C \subseteq \bigcap_{e \in E} e.$$

We say that $\mathcal{H}$ has center size $t = |\bigcap_{e \in E} e|$.

Definition 2.3. *Let $\mathcal{H}$ be a uniform hyperstar. We call $\mathcal{H}$ an umbrella if we can order the edges $e_1, e_2, \ldots, e_\ell$ of $\mathcal{H}$ such that $e_1 \setminus e_2, e_2 \setminus e_3, \ldots, e_{\ell-1} \setminus e_\ell, e_\ell \setminus e_1$, are pairewise disjoint sets of cardinality one. See Figure 1 for an example of an umbrella hypergraph.*

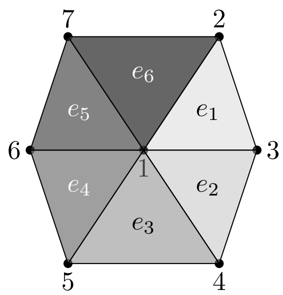

Figure 1: A 3-uniform umbrella with center size 1.

Let $S = k[x_1, \ldots, x_n]$ be the polynomial ring over a field k.

Definition 2.4. *The edge ideal of a hypergraph $\mathcal{H} = (V, E)$ is the monomial ideal*

$$I(\mathcal{H}) = (x_{i_1} \ldots x_{i_s} : \{i_1, \ldots, i_s\} \in E(\mathcal{H})) \subset S.$$

Definition 2.5. *Let I be a non-zero homogeneous ideal of S, and suppose that $\alpha(I) = min\{d | I_d \neq 0\}$ be the smallest degree of a non-zero element in I. The Waldschmidt constant of I is*

$$\hat{\alpha}(I) = \lim_{m \to \infty} \frac{\alpha(I^{(m)})}{m}.$$

Let $\mathcal{H} = (V, E)$ be a hypergraph. A list assignment L of $\mathcal{H}$ is a function which assigns a set L_v to each $v \in V$. The sets are called lists and their elements are called colors. A list coloring of $\mathcal{H}$ is an assignment of a color from L_v to each $v \in V$ such that every edge of $\mathcal{H}$ contains a pair of vertices of different colors.

Definition 2.6 ([15]). *A hypergraph $\mathcal{H}$ with vertex set V and hyperedge set E is called (a, b)-choosable if for every list assignment L with $|L_v| = a$ for all $v \in V$, we can choose subsets $C_v \subseteq L_v$ such that $|C_v| = b$ and for all $e \in E$,*

$$\bigcap_{v \in e} C_v = \emptyset.$$

By [15, Theorem 3], one may define the fractional chromatic number of a hypergraph as follows:

Definition 2.7. *The fractional chromatic number of a hypergraph $\mathcal{H}$ is $inf\{\frac{a}{b} | H \text{ is a } (a, b) - choosable\}$ and is denoted by $\chi^\star(H)$.*

Definition 2.8. *Let I be a non-zero homogeneous ideal of S and $m \in \mathbb{N}$. The symbolic defect* sdefect(I, m) *is the number $\mu_m = \mu(I^{(m)}/I^m)$ of minimal generators $F_1, \ldots, F_{\mu_m}$ of $I^{(m)}/I^m$ as an S-module such that*

$$I^{(m)} = I^m + (F_1, \ldots, F_{\mu_m}).$$

Definition 2.9. *Let $G = (V, E)$ be a graph on the vertex set $[n]$. The binomial edge ideal J_G of G is the ideal of the polynomial ring $k[x_1, \dots, x_n, y_1, \dots, y_n]$ over a field k, generated by binomials $f_{i,j} = x_i y_j - y_i x_j$ which $\{i, j\} \in E(G)$.*

Remark 2.10. *For a squarefree monomial ideal I, the n-th symbolic power of I is*

$$I^{(n)} = \bigcap_{p \in \mathrm{Ass}(S/I)} p^n.$$

This is a consequence of the fact that squarefree monomial ideals have no embedded prime ideal; see for example [6, Theorem 3.7] and the discussion after that.

3. Waldschmidt Constant

Throughout this article, the vector $\mathbf{1}$ denotes the vector with all entries equal to 1, and $\mathbf{0}$ denotes the vector with all entries equal to 0. By the following result, one can obtain the Waldschmidt constant by finding the solution of a linear program:

Theorem 3.1 ([2, Theorem 3.2]). *Let $I \subseteq S$ be a squarefree monomial ideal with minimal primary decomposition $I = P_1 \cap P_2 \cap \cdots \cap P_s$ where $P_j = (x_{j_1}, \dots, x_{j_{s_j}})$ for $j = 1, \dots, s$. Assume that A is the $s \times n$ matrix with the following entries:*

$$A_{ij} = \begin{cases} 1 & \text{if } x_j \in P_i, \\ 0 & \text{if } x_j \notin P_i. \end{cases}$$

Consider the following linear program:
Find a vector y that
Minimize $\mathbf{1}^T y$;
Subject to $Ay \geq \mathbf{1}$ and $y \geq \mathbf{0}$;
and suppose that $y^\star$ is a solution that realizes the optimal value. Then

$$\hat{\alpha}(I) = \mathbf{1}^T y^\star,$$

that is, $\hat{\alpha}(I)$ is the value of the above described linear program.

Theorem 3.2. *Let I be the edge ideal of a $(t+m)$-uniform umbrella hyperstar of center size t on $t+n$ vertices. Then we have*

$$\hat{\alpha}(I) = \begin{cases} t+m & \text{if } n = mk \text{ for some } k, \\ t+m-\dfrac{m-r}{k+1} & \text{if } n = mk+r \text{ for some } k \text{ with } 0 < r < m. \end{cases}$$

Proof. Let $e_1, \dots, e_\ell$ be the suitable ordering of edges according to the Definition 2.3. By a suitable relabeling of vertices, the edge ideal of this hypergraph is

$$I = (x_1 x_2 \dots x_t x_i x_{a_{i+1}} \dots x_{a_{i+m-1}} \ : \ i \in \{t+1, \dots, t+n\} \text{ and } a_j = j \quad \text{if } j \leq t+n, \text{ and } a_j = j-n \quad \text{if } j > t+n).$$

We know that $\{1\}, \dots, \{t\}$ are minimal vertex cover for $\mathcal{H}$. So

$$P_1 = (x_1), \dots, P_t = (x_t),$$

are among the minimal prime ideals of I. Set $P_{t+1} = (x_{t+1}, x_{t+1+m}, \dots, x_{t+1+sm})$, where s is the integer for which $\{t+1, t+1+m, \dots, t+1+sm\}$ is a minimal vertex cover of $\mathcal{H}$. We can also set $P_{t+2}, \dots, P_{t+n}$ by shifting indices of P_{t+1}, that is,

$$P_{t+i} = (x_{a_{t+i}}, x_{a_{t+i+m}}, \dots, x_{a_{t+i+sm}} : \ a_j = j \text{ if } j \leq t+n \text{ and } a_j = j-n \text{ if } j > t+n).$$

Considering the ideals $P_{t+1}, \dots, P_{t+n}$, the variable x_{t+1+sm} exactly belongs to $s+1$ ideals

$$P_{t+1}, P_{t+1+m}, \dots, P_{t+1+sm}.$$

Similarly one has the same property for the other variables except than $x_1, \dots, x_t$. Now $t+n$ distinct minimal vertex covers are known and the cardinality of every other minimal vertex cover (if exists) is greater or equal to these $t+n$ minimal vertex covers. Regarding the matrix described in Theorem 3.1, we consider the submatrix by $t+n$ rows corresponding to these $t+n$ minimal prime ideals, that is,

$$\tilde{A} = \begin{pmatrix} 1 & 0 & \dots & 0 & 0 & \dots & \dots & \dots & 0 \\ 0 & 1 & \dots & 0 & 0 & \dots & \dots & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & 1 & 0 & \dots & \dots & \dots & 0 \\ 0 & 0 & \dots & 0 & 1 & \dots & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & 0 & 0 & \dots & \dots & \dots & 1 \end{pmatrix}.$$

By considering the first t rows of the matrix we have $y_i \geq 1$ for $i = 1, \dots, t$ and so

$$y_1 + \dots + y_t \geq t. \tag{1}$$

Now by considering the next n rows of the matrix we have

$$(s+1)(y_{t+1} + \dots + y_{t+n}) \geq n. \tag{2}$$

By Theorem 3.1,

$$\hat{\alpha}(I) \geq t + \frac{n}{s+1}.$$

Notice that $[\underbrace{1, \dots, 1}_{t \text{ times}}, \underbrace{\frac{1}{s+1}, \dots, \frac{1}{s+1}}_{n \text{ times}}]$ is a feasible solution of $\tilde{A}y \geq \mathbf{1}$. Recall that the rows of matrix A in Theorem 3.1 which do not appear in $\tilde{A}$ have more or equal nonzero entries. So we have $Ay \geq \mathbf{1}$ and consequently,

$$\hat{\alpha}(I) \leq t + \frac{n}{s+1}.$$

So

$$\hat{\alpha}(I) = t + \frac{n}{s+1}.$$

Now we compute s:

Case 1. Let $n = mk$ for some k. Then $\{t+1, t+1+m, \dots, t+1+(k-1)m\}$ is a minimal vertex cover of $\mathcal{H}$. Hence in this case $s = k-1$.

Case 2. Let $n = mk + r$ for some k with $1 \leq r < m$. If we consider the subset $C = \{t+1, \dots, t+1+(k-1)m\}$, one can see that

$$t + 1 + (k-1)m < t + n - m + 1.$$

Thus the edge $\{t+n-m+1, \dots, t+n\}$ is not covered by C. On the other hand,

$$t + n - m + 1 \leq t + 1 + km \leq t + n.$$

As a result by adding $t+1+km$ to C, we obtain a minimal vertex cover of $\mathcal{H}$. So $s = k$, and

$$\hat{\alpha}(I) = t + \frac{n}{k+1} = t + \frac{mk+r}{k+1} = t + \frac{mk+m-m+r}{k+1} = t + m - \frac{m-r}{k+1}.$$

□

Remark 3.3. *The path ideal of length $m-1$ associated with a graph G is the monomial ideal*

$$I_m(G) = (x_{i_1} \dots x_{i_m} | x_{i_1}, \dots, x_{i_m} \textit{is a path in } G) \subset S.$$

When $t = 0$, the edge ideal of a uniform umbrella is a path ideal of a cycle whose Waldschmidt constant is considered in [1, Proposition 4.7].

Proposition 3.4 ([9, Lemma 2]). *Let $\mathcal{H}$ be a hypergraph that has a hyperedge with k elements. Then*

$$\chi^\star(\mathcal{H}) \geq \frac{k}{k-1},$$

where $\chi^\star(\mathcal{H})$ is the fractional chromatic number of the hypergraph $\mathcal{H}$.

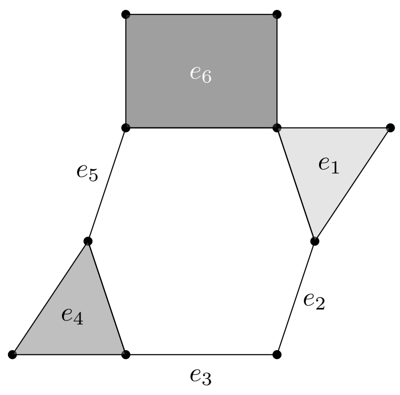

Figure 2: A wheel hypergraph on C_6.

Proposition 3.5 ([2, Theorem 4.6]). *Suppose that $\mathcal{H} = (V, E)$ is a hypergraph with at least one edge of cardinality > 1, and let $I = I(\mathcal{H})$. Then*

$$\hat{\alpha}(I) = \frac{\chi^\star(\mathcal{H})}{\chi^\star(\mathcal{H}) - 1},$$

where $\chi^\star(\mathcal{H})$ is the fractional chromatic number of the hypergraph $\mathcal{H}$.

Definition 3.6. *Let $\mathcal{H}$ be a hypergraph. We call H a wheel if its edges rely on the edges of a cycle graph.*

See Figure 2 for an example of a wheel hypergraph.

Theorem 3.7. *Let $\mathcal{H}$ be a wheel hypergraph such that at least one of its edges has more than 3 vertices. Then the Waldschmidt constant of $I(\mathcal{H})$ is equal to the number of vertices of the smallest edge.*

Proof. Assume that k is the smallest cardinality of edges of $\mathcal{H}$. Then according to Proposition 3.4, we know that the fractional chromatic number of $\mathcal{H}$ is greater than or equal to $\frac{k}{k-1}$. Therefore, it suffices to show that $\mathcal{H}$ is $(k, k-1)$-choosable.

Let C_n be the cycle graph that all edges of wheel hypergraph $\mathcal{H}$ rely on. Set $A_i = [k] \setminus \{i\}$. Consider the list assignment L that $L_v = [k]$ for every vertex v of $\mathcal{H}$. We choose subsets $C_v \subseteq L_v$ for the vertices of the cycle C_n as follows: we choose C_v such that A_1 and A_2 are chosen for vertices of C_n exactly every other step, probably except than two adjacent vertices v_i and v_j which an edge of size ≥ 3 rely on $\{v_i, v_j\}$. Consider an arbitrary edge $e = \{v_1, \ldots, v_k, v_{k+1}, \ldots, v_{k+\ell}\}$, and assume that v_1 and v_2 are on the cycle C_n. choose the subset $C_{v_i} = A_i$ for $i = 3, \ldots, k$, and $C_{v_i} = A_1$ for $i \geq k+1$. Then

$$\bigcap_{i=1}^{k} C_{v_i} = \emptyset.$$

In particular, $\bigcap_{i=1}^{k+\ell} C_{v_i} = \emptyset$. Hence $\mathcal{H}$ is $(k, k-1)$-choosable. □

Theorem 3.8. *Let J_G be the binomial edge ideal of a graph G, then*

$$\hat{\alpha}(J_G) = 2.$$

Proof. By [11, Corollary 3.9], we know that the binomial edge ideal $J_{\tilde{G}}$ of the complete graph on $V(G)$ appears in the primary decomposition of J_G. It is known by the argument before [7, Proposition 2.3] that for the associated prime ideal $J_{\tilde{G}}$, we have $J_{\tilde{G}}^{(t)} = J_{\tilde{G}}^t$ for every t. So for each $f \in J_G^{(t)}$, the product of at least t binomials f_{ij} divides each summand of f. So $\alpha(J_G^{(t)}) \geq 2t$. On the other hand, we have

$$\alpha(J_G^{(t)}) \leq \alpha(J_G^t) \leq t\alpha(J_G) = 2t.$$

So $\hat{\alpha}(J_G) = 2$. □

4. Symbolic Defect

In this section, we are going to present a formula for the symbolic defect of umbrella hypergraphs. First, consider the following result:

Proposition 4.1 ([12, Corollary 5.3, Corollary 5.4, Theorem 5.13] and [17, Theorem 5.9]). *Let C_n be a cycle graph on n vertices and $I = I(C_n) \subset k[x_1, \dots, x_n]$ be its edge ideal, then*

1. *If $n = 2k$, then* $\operatorname{sdefect}(I, s) = 0$ *for every* $s \geq 1$.

2. *If $n = 2k + 1$, then*

- *(a)* $\operatorname{sdefect}(I, s) = 0$ *for every* $1 \leq s \leq k$.
- *(b)* $\operatorname{sdefect}(I, k + 1) = 1$ *and* $I^{(k+1)} = I^{k+1} + (x_1 \dots x_{2k+1})$.
- *(c)* $\operatorname{sdefect}(I, s) = \binom{s+k-1}{s-k-1}$ *for every* $k + 2 \leq s \leq 2k + 1$.

Theorem 4.2. *Let $J = (x_1 \dots x_t x_i x_{i+1}, x_1 \dots x_t x_{t+1} x_{t+n} : t + 1 \leq i \leq t + n - 1) \subset k[x_1, x_2, \dots, x_{t+n}]$ be the edge ideal of a $(t + 2)$-uniform umbrella hypergraph, then*

1. *If $n = 2k$, then* $\operatorname{sdefect}(J, s) = 0$ *for every* $s \geq 1$.
2. *If $n = 2k + 1$, then*
   - *(a)* $\operatorname{sdefect}(J, s) = 0$ *for every* $1 \leq s \leq k$.
   - *(b)* $\operatorname{sdefect}(J, k + 1) = 1$ *and* $J^{(k+1)} = J^{k+1} + (x_1 \dots x_t x_{t+1} \dots x_{t+2k+1})$.
   - *(c)* $\operatorname{sdefect}(J, s) = \binom{s+k-1}{s-k-1}$ *for every* $k + 2 \leq s \leq 2k + 1$.

Proof. Let $I = I(C_n) \subset k[x_{t+1}, x_{t+2}, \dots, x_{t+n}]$ be the edge ideal of C_n, then

$$J = (x_1 \dots x_t)I.$$

In particular, in $k[x_1, x_2, \dots, x_{t+n}]$, for each s we have

$$(x_1 \dots x_t)^s I^s = (x_1 \dots x_t)^s \cap I^s,$$

and consequently

$$J^s = ((x_1 \dots x_t)I)^s = (x_1 \dots x_t)^s I^s = (x_1 \dots x_t)^s \cap I^s.$$

Since the minimal monomial generators of I and $(x_1 \dots x_t)$ are defined by two disjoint sets of variables, and by Remark 2.10, we have

$$J^{(s)} = (x_1 \dots x_t)^s \cap I^{(s)} = (x_1 \dots x_t)^s \cap p_1^s \cap \dots \cap p_\ell^s,$$

where $p_1, \dots, p_\ell$ are minimal prime ideals of I. Setting $L = (F_1, \dots, F_m)$ such that

$$I^{(s)} = I^s + (F_1, \dots, F_m),$$

and $m = \mu_s$. We have

$$J^{(s)} = (x_1 \dots x_t)^s \cap (I^s + L).$$

On the other hand, we have

$$(x_1 \dots x_t)^s \cap (I^s + L) = ((x_1 \dots x_t)^s \cap I^s) + ((x_1 \dots x_t)^s \cap L).$$

So

$$J^{(s)} = J^s + ((x_1 \dots x_t)^s \cap L).$$

Since we have $(x_1 \dots x_t)^s L = (x_1 \dots x_t)^s \cap L$, one has

$$J^{(s)} = J^s + (x_1^s \dots x_t^s F_1, \dots, x_1^s \dots x_t^s F_m).$$

As a result

$$\operatorname{sdefect}(J, s) = \operatorname{sdefect}(I, s) \qquad s \geq 1.$$

Now by Proposition 4.1, we obtain the desired result. ☐

References

[1] A. Alilooee and A. Banerjee, *Symbolic powers of multipartite hypergraphs and Waldschmidt constant*, arXiv preprint, (2021).

[2] C. Bocci, S. Cooper, E. Guardo, B. Harbourne, M. Janssen, U. Nagel, A. Seceleanu, A. Van Tuyl, and T. Vu, *The Waldschmidt constant for squarefree monomial ideals*, J. Algebraic Combin., 44 (2016), pp. 875–904.

[3] C. Bocci and B. Franci, *Waldschmidt constants for Stanley-Reisner ideals of a class of simplicial complexes*, J. Algebra Appl., 15 (2016), pp. 1650137, 13.

[4] E. Camps Moreno, C. Kohne, E. Sarmiento, and A. Van Tuyl, *On the Waldschmidt constant of square-free principal Borel ideals*, Proc. Amer. Math. Soc., 150 (2022), pp. 4145–4157.

[5] B. Chakraborty and M. Mandal, *Invariants of the symbolic powers of edge ideals*, J. Algebra Appl., 19 (2020), pp. 2050184, 19.

[6] S. M. Cooper, R. J. D. Embree, H. T. Hà, and A. H. Hoefel, *Symbolic powers of monomial ideals*, Proc. Edinb. Math. Soc. (2), 60 (2017), pp. 39–55.

[7] V. Ene and J. Herzog, *On the symbolic powers of binomial edge ideals*, in Combinatorial structures in algebra and geometry, vol. 331 of Springer Proc. Math. Stat., Springer, Cham, [2020] ©2020, pp. 43–50.

[8] F. Galetto, A. V. Geramita, Y.-S. Shin, and A. Van Tuyl, *The symbolic defect of an ideal*, J. Pure Appl. Algebra, 223 (2019), pp. 2709–2731.

[9] D. R. Gaur and K. Makino, *On the fractional chromatic number of monotone self-dual Boolean functions*, Discrete Math., 309 (2009), pp. 867–877.

[10] Y. Gu, H. T. Hà, J. L. O'Rourke, and J. W. Skelton, *Symbolic powers of edge ideals of graphs*, Comm. Algebra, 48 (2020), pp. 3743–3760.

[11] J. Herzog, T. Hibi, F. Hreinsdóttir, T. Kahle, and J. Rauh, *Binomial edge ideals and conditional independence statements*, Adv. in Appl. Math., 45 (2010), pp. 317–333.

[12] M. Janssen, T. Kamp, and J. Vander Woude, *Comparing powers of edge ideals*, J. Algebra Appl., 18 (2019), pp. 1950184, 19.

[13] A. V. Jayanthan, A. Kumar, and V. Mukundan, *On the resurgence and asymptotic resurgence of homogeneous ideals*, Math. Z., 302 (2022), pp. 2407–2434.

[14] P. Mantero and V. Nguyen, *The structure of symbolic powers of matroids*, Trans. Amer. Math. Soc., 379 (2026), pp. 3855–3894.

[15] P. Mihók, Z. Tuza, and M. Voigt, *Fractional $\mathcal{P}$-colourings and $\mathcal{P}$-choice-ratio*, Tatra Mt. Math. Publ., 18 (1999), pp. 69–77.

[16] B. Oltsik, *Symbolic defect of monomial ideals*, Comm. Algebra, 52 (2024), pp. 3996–4012.

[17] A. Simis, W. V. Vasconcelos, and R. H. Villarreal, *On the ideal theory of graphs*, J. Algebra, 167 (1994), pp. 389–416.

[18] T. Szemberg and J. Szpond, *Waldschmidt constants for Stanley-Reisner ideals of a class of graphs*, in Multigraded algebra and applications, vol. 238 of Springer Proc. Math. Stat., Springer, Cham, 2018, pp. 159–167.

Please cite this article using:

Iman Jahani, Shamila Bayati, Waldschmidt constant of some classes of hypergraphs, AUT J. Math. Comput., 7(4) (2026) 391-397
https://doi.org/10.22060/AJMC.2024.23561.1266